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TABLE OF CONTENTS

LARGE SUPPLY MAINS. By Dabney H. Maury.....	1
GOVERNMENT REQUIREMENTS AND PROFESSIONAL STANDARDS. By George C. Whipple.....	61
IODINE TREATMENT OF THE ROCHESTER WATER SUPPLY. By Beekman C. Little.....	68
WATER WORKS INFORMATION. By F. C. Jordan.....	87
DEVELOPMENT OF WATER PURIFICATION. By George W. Fuller.....	100
SEDIMENTATION IN THE PURIFICATION OF WATER AT CEDAR RAPIDS, IOWA. By C. O. Bates.....	104
MUNICIPAL WATER SOFTENING IN ILLINOIS. By A. M. Buswell.....	107
EFFECT OF NEW IMPOUNDING RESERVOIR ON FILTER PLANT OPERATION AT DECATUR. By W. E. Stanley and E. E. Ruthrauff.....	110
SOCIETY AFFAIRS.....	127
ABSTRACTS.....	136
METHODS OF MAKING FLOW TESTS AND THEIR VALUE TO WATER WORKS ENGINEERS. By George W. Booth.....	157
THE RELATION OF FIRE PROTECTION REQUIREMENTS TO THE DISTRIBUTION SYSTEM OF SMALL TOWNS. By Clarence Goldsmith.....	168
THE ECONOMIC SIGNIFICANCE OF FIRE WASTE. By Franklin H. Wentworth	179
DISCUSSION OF FIRE PROTECTION REQUIREMENTS IN DISTRIBUTION SYSTEM DESIGN. By J. H. Howland, V. B. Siems and Wm. Luscombe....	186
RELATIVE ECONOMY OF STANDBY OIL ENGINES. By W. S. Lea.....	191
A NEW DIFFERENTIAL TEST FOR MEMBERS OF THE COLON GROUP OF BACTERIA. By Stewart A. Koser.....	200
THE MOST INTERESTING EXPERIENCE RECENTLY ENCOUNTERED IN WATER TREATMENT. TOPICAL DISCUSSION. By J. W. Armstrong, J. R. Baylis, W. R. Gelston, F. W. Green, C. R. Henderson, C. P. Hoover, N. J. Howard, M. C. Whipple, L. H. Enslow, E. S. Chase, T. D. L. Coffin and G. R. Taylor.....	206
ABSTRACTS.....	250
MANUAL OF AMERICAN WATER WORKS PRACTICE. PRELIMINARY STATEMENT.....	267
THE CHLORINATION OF SMALL WATER SUPPLIES. By M. F. Tiernan....	272
SUPERVISION OF WATER TREATMENT PLANTS IN MICHIGAN. By E. D. Rich.	282
THE CHEMISTRY OF INTERIOR BOILER WATER TREATMENT. By E. M. Partridge.....	288
PACKING. By John W. Mabbs.....	295
ALLOCATION OF WATER SUPPLIES DERIVED FROM THE WATER SHEDS OF INTERSTATE STREAMS. By Morris Knowles.....	297
PUMPING STATION BETTERMENTS. TOPICAL DISCUSSION.....	301

SUPERINTENDENTS' QUESTION BOX SERIES:

Seasonal Delivery of Water Works Material to Avoid Freight	
Congestion.....	305
Tastes Due to Algae Growths.....	307
Flushometer Water Closets.....	312
Helpful Tools in Removing Meters.....	316
Pipe Joint Materials.....	320
Locating Leaks.....	323
Resetting Meters and Meter Location Records.....	328
Automatic Sprinkler Charges and Regulations.....	331
The Size of Fire Services.....	336
Protection of Fire Hydrants.....	339
Dry Weather Conditions Causing Shortage of Water.....	340
Indexing and Clipping Articles.....	344
Segregation of Water Rates.....	346
Forestation of Water Sheds.....	348
Advance Placement of Service.....	351
Water, Sewer and Gas Pipe in Same Trench.....	353
Care of Hydrant Drips in Wet Soil.....	354
Cross Connections.....	355
DISCUSSION. By A. M. Buswell and R. A. Shive.....	358
ABSTRACTS.....	360
OPERATING EXPERIENCES AND ECONOMY OF A DIESEL ENGINE DRIVEN	
PUMPING STATION. By W. DeWitt Vosbury.....	381
CURRENT PRACTICE IN THAWING FROZEN SERVICES AND HYDRANTS. By	
F. A. McInnes and J. M. Goodell.....	393
SOFTENING OF PUBLIC WATER SUPPLIES. By G. S. Strout.....	398
COMPOSITION OF ALUM FLOC IN MIXING BASIN. By E. S. Hopkins.....	405
DISCUSSION OF REPORT OF COMMITTEE NO. 6 ON INDUSTRIAL WASTES IN	
RELATION TO WATER SUPPLY.....	410
THE ACTION OF WATER ON SERVICE PIPES. DISCUSSION.....	417
DISCUSSION OF REPORTS OF COMMITTEE NO. 7 ON PUMPING STATION	
BETTERMENTS.....	428
DISCUSSION: COLORIMETRIC DETERMINATION OF TOTAL ALUMINA IN	
WATER. By F. O. Baldwin.....	439
ABSTRACTS.....	441

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The Association is not responsible, as a body, for the facts and opinions advanced in any of the papers or discussions published in its proceedings
Discussion of all papers is invited

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No. 1

LARGE SUPPLY MAINS¹

BY DABNEY H. MAURY²

Not many decades ago the cities and towns of this country got their water supply from wells or surface sources close at hand. The rapid growth of urban population has compelled one city after another to go further afield for its water supply. In some cases the capacity of the adjacent wells or stream or lake became inadequate to meet the demands of the community. More often, however, the pollution of the local supply made it necessary to seek another and more distant source.

Conspicuous examples of American cities which have gone far afield for water are Los Angeles, which brought in a new supply from 235 miles away; San Francisco, 154 miles; New York, 120 miles; Tulsa, Oklahoma, 60 miles; Phoenix, Arizona, 32 miles; Butte, Montana, 27 miles; Denver, 25 miles; and Norfolk and Portsmouth, Virginia, about 20 miles each.

In Canada, the city of Winnipeg brought in a new supply a total distance of 98 miles, while Victoria went 38 miles for its water.

In Australia the Coolgardie pipe line is 351 miles in length, while the Apulian Aqueduct now being constructed to supply 266 communities in southern Italy will have 152 miles of main trunk conduit and 841 miles of main and subsidiary branches leading therefrom.

¹ Presented before the New York Convention, May 21, 1924.

² Consulting Engineer, Chicago, Ill.

Many other instances could be cited, and their number is increasing rapidly. At least one other pipe line, of more than 100 miles in length, is already under contemplation in this country.

Enough has been said to show that the near future will see a very large amount of capital invested in supply mains, and that the economic design of these mains is a live and important problem.

It will be the purpose of this paper to describe briefly the principal types of pipe available for large supply mains, to present approximate estimates of their respective first costs for various diameters and pressures, to set forth their respective advantages and disadvantages, and to endeavor to put a financial value on these advantages and disadvantages, to the end that the several pipes may ultimately be compared on a dollar-and-cent basis.

HISTORICAL

Cast iron pipe

The earliest recorded use of cast iron water mains appears to have been in Versailles, France, where several miles of cast iron pipe in lengths of one meter, and with flanged joints, were installed between 1685 and 1688, or more than 235 years ago. These mains are reported to be still in service. A number of other cities in France, as well as cities in Belgium, Holland, Germany, Austria and England laid cast iron mains more than 100 years ago.

The Gas Light Company of Baltimore, which was founded in 1816, installed cast iron bell and spigot mains immediately thereafter; while the City of Philadelphia laid cast iron bell and spigot water mains as early as 1817. Troy installed cast iron water mains at least as early as 1833; Boston in 1848; New York at some time prior to 1850, and Toronto in 1854. It is quite possible that there are some other American cities which laid cast iron mains earlier than any of these just mentioned, with the exception of Baltimore and Philadelphia.

Following the earlier installations above recorded, the use of cast iron bell and spigot pipe, especially for water works and gas distribution systems, increased so rapidly in this country as to become almost universal.

Steel pipe

Although steel has of late years been the material commonly used for wrought pipe, it was preceded in this field by wrought

iron. The first pipes or tubes made were apparently used for gun barrels, the bent plates for which were laboriously welded together by hand over a mandrel.

In 1812 an Englishman named Osborn patented machinery for welding and making barrels of firearms and other cylindrical articles. A little later another Englishman, Murdoch, collected and used old gun barrels, screwing them together into a continuous tube for conveying gas, the process of making gas from coal having recently been invented.

In 1824 James Russell devised improvements in the manufacture of tubes for gas and other purposes.

In 1825 Cornelius Whitehouse invented a process of butt-welding wrought iron tubes.

The growing demand for tubular products was met by the establishment of more and more plants for making them, and to the firm of Morris, Tasker & Morris of Philadelphia belongs credit for having built, in 1830-1834, the first furnace in the United States for making butt-welded pipe. In 1836 the same firm erected other plants, including furnaces, mills and machine shops.

In 1847 James J. Walworth sailed to England to investigate the tube making industry in that country, and the year 1849 saw the manufacture of 1-inch pipe, $\frac{3}{4}$ -inch pipe and 3-inch flues.

The small plant which formed the nucleus of the many enormous works of the present National Tube Company was established in East Boston in 1868.

While the use of riveted pipe in this country dates back about three-quarters of a century, no such accurate records are available with regard to it as have been secured with regard to cast iron pipe and welded pipe by the efficient publicity departments of the United States Cast Iron Pipe & Foundry Company, and the National Tube Company.

Mr. S. B. Morris, in his paper read before the California Section of the American Water Works Association in 1923, mentions a 30-inch 12-gauge riveted iron pipe laid in 1868, some of which continued in full service for fifty-four years.

At the Philadelphia Convention in 1922 Mr. Theodore A. Leisen cited a 50-inch riveted pipe installed at Pittsburgh in 1871, a 62-inch riveted steel pipe installed for the Detroit Water Works at least forty-seven years ago, a 50-inch riveted steel main laid in Allegheny, Pa., twenty-nine years ago; a 48 inch riveted steel pipe

laid near Newark, N. J., twenty-nine years ago; and 4 miles of 43-inch and 48-inch Lock-Bar steel mains laid in Wilmington, Del., nineteen years ago. Other and earlier large installations of lock-bar pipe are the 12 miles of 15-inch, 24-inch and 26-inch pipe laid in 1897 for the City of Adelaide, Australia; and the famous Coolgardie, Australia, line, 351 miles long and 30 inches in diameter. Perhaps the best known early example of riveted mains for municipal water supply is the Rochester conduit, consisting of 9.62 miles of 36-inch and 2.92 miles of 24-inch wrought iron pipe, laid in 1875.

There are now scores of large cities in this country using wrought iron or steel mains of considerable length and size for water supply or distribution. Some of these mains are riveted, some are of spiral pipe, some are of the lock-bar type, some, of relatively small size, are lap-welded; and a few of the later ones are of the new hammer-weld type, which is the most recent development in the art of making large steel pipe.

Concrete pipe

Precast reinforced concrete pipe has been in use for sewers for 40 or 50 years, taking the place of the larger sizes of vitrified tile pipe and of the smaller sizes of brick masonry or monolithic concrete sewers. It was not until about 30 years ago that serious efforts were made to develop a precast reinforced concrete pipe for conveying water under pressure. The earlier pipes had cement joints like those of tile pipes; joints were developed later in which the cement was applied around a steel mesh projecting from the ends of the pipe. Conduits built of pipe so constructed were naturally too rigid to allow much contraction or settlement.

Within the last decade, however, great improvements have been made in precast reinforced concrete pipe for water supply, and there are now available pipes of this material in 12-foot lengths having unusually smooth interior surfaces, and joints made with lead gaskets which will permit, without material leakage, a relatively large amount of expansion, contraction or settlement. These pipes can be had over a wide range of diameters and for heads up to at least 250 feet.

Wood pipe

The earliest supply mains in common use in this country were bored logs, some of which were doubtless installed more than two

hundred years ago. A number of them remained in service for more than fifty years. These bored logs at first had no metal reinforcement, but, in the course of time, manufacturers began to strengthen the ends of the logs with steel bands.

In 1860 a patent was granted to Mr. A. Wyckoff, of Elmira, New York, for an auger which bored a log, taking out a core in such a manner that the core itself could be rebored with a smaller auger, thus enabling two or more pipe shells of different sizes to be made from one log.

The earliest recorded instance of a built-up pipe of any considerable size, consisting of wooden staves held in place by steel or iron bands, is that of a penstock 6 feet in diameter which was installed in 1874 at Manchester, New Hampshire, by the late Mr. J. T. Fanning, one of the best known hydraulic engineers of his time. This penstock, which was probably of white pine, then quite abundant, is said to have remained in service until 1913.

For the first introduction of continuous wood stave pipe on a larger scale, credit is due to Mr. C. P. Allen, Chief Engineer of the Denver Union Water Company, who, beginning about 1880, built many miles of wood stave pipe of a type which embodies most of the essential features of design now found in the best modern continuous wood stave pipe. The shoes now used for joining the ends of the bands on continuous wood stave pipe follow closely the early designs of Mr. Allen, and are frequently referred to as the "Allen" type of shoe.

A few years later the construction of wood stave pipe was undertaken on a commercial basis by companies in New York and Michigan, which used white pine for their staves, and shortly thereafter, by several companies on the Pacific Coast, using redwood and fir.

As a result of the formation of these companies, the commercial manufacture of machine banded or wire wound pipe had its origin, some of the manufacturers banding their pipes with flat iron or steel hoops wound spirally around the staves, while others used round wire for the same purpose. Very large quantities of wood stave pipe of the machine banded type, as well as of the continuous stave type, are now in use, especially in the western portions of the United States, although within the last few years the war necessities of the country and the tremendous increase in the prices of cast iron and steel pipe have resulted in the introduction of hundreds of miles of wood stave pipe in territory east of the Rocky Mountains. Over

700 miles of wood pipe, from 6-inch to 30-inch in diameter, were installed under the author's direction for the camps, cantonments and other war activities of the United States Army. Many pipe lines of much larger size are now in use either as supply lines to cities or as penstocks for hydro-electric installations. Many of these lines are more than 6 feet in diameter and some of them are as large as 14 feet.

There are also some cities or towns in which machine banded wood stave pipe is in use for distribution mains, and with what are said to be satisfactory results. A notable example is Valparaiso, Indiana, whose entire distribution system is of machine banded Michigan pine pipe. But because wood stave pipe is less durable than cast iron pipe, and, as a rule, leaks much more, it is not usually considered good practice to lay it under pavements, as these pavements would have to be cut and renewed at great expense whenever a leak occurred.†

PIPES NOW AVAILABLE

As a result of all of these developments, the engineer charged with the design of a supply main has at the outset four principal materials to choose from; viz., cast iron, steel, reinforced concrete, and wood.

In the case of each material, there are two or more types of pipe at his disposal. For instance, he has available cast iron bell and spigot pipe, made in accordance with the Standard Specifications of the American Water Works Association or of the New England Water Works Association; or, over a limited range of small sizes, he can have the same sort of pipe made by the centrifugal process; or, he can use what is known as the "high tensile strength" bell and spigot cast iron pipe.

In steel pipe the principal types would be riveted, spiral, lock-bar, and hammer-weld pipe, with various types of joints.

If he should decide to make his supply main of reinforced concrete, he could build either a monolithic concrete conduit, or adopt one of several types of precast concrete pipe, with joints at intervals of from 3 to 12 feet.

In the field of wood stave pipe, he could use a pipe of the machine banded type for sizes up to 24-inch, and pipe of the continuous stave type for sizes 20-inch and larger. The staves themselves might be either redwood, fir or pine.

PROCESS OF MANUFACTURE

Cast iron

The first cast iron mains laid abroad were flanged pipe. The earliest bell and spigot pipes laid in America came from abroad, were made in lengths of from 3 to 6 feet and were cast on the side. Somewhat later bell and spigot pipes were made in 9-foot lengths and cast in a sloping position. Still later the length was increased to 12 feet and the pipes were cast vertically, with the bell end up. Some bell



FIG. 1. CASTING PIPE VERTICALLY

and spigot pipes have been made in 16-foot lengths. Standard bell and spigot pipe are at present usually cast with the bell end down. A surplus of metal is poured on top of the spigot end, and this surplus, which carries most of the impurities, is then cut off, leaving the spigot sound and true.

Figure 1 shows the modern method of casting pipe in a vertical position.

The cores for pipe casting are made by wrapping ropes of straw around drums of the proper size and plastering a smooth surface of



FIG. 2. MAKING STRAW ROPES

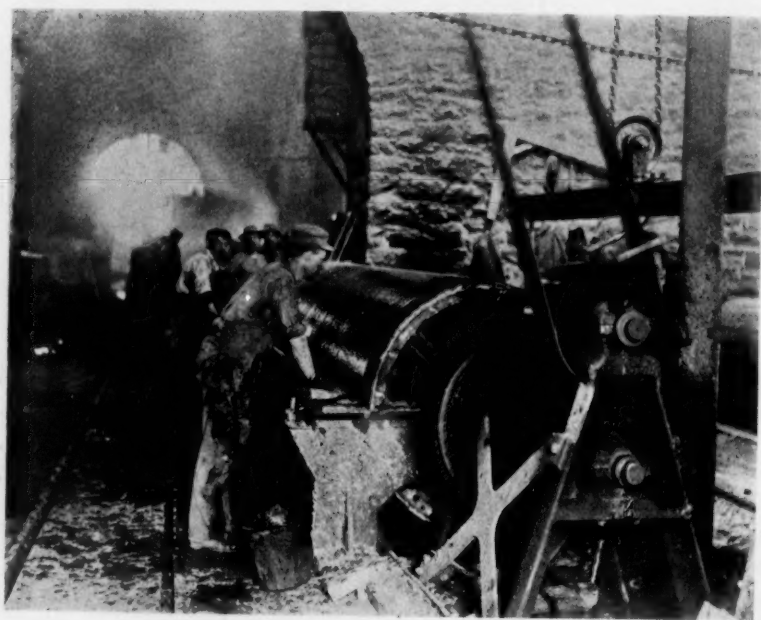


FIG. 3. WINDING STRAW ROPES ON CORE

clay over the straw. Figure 2 shows the method of making the straw ropes, and figure 3, the winding of the straw ropes on the drums.

The so-called high tensile strength cast iron pipe is made in exactly the same manner as the standard bell and spigot pipe, but the chemical constituents of the cast iron are so changed as to add about 30 per cent to its tensile strength, thus reducing the thickness of shell required for any given head. The pipe so made costs somewhat less, but is a trifle more brittle than the standard cast iron pipe.

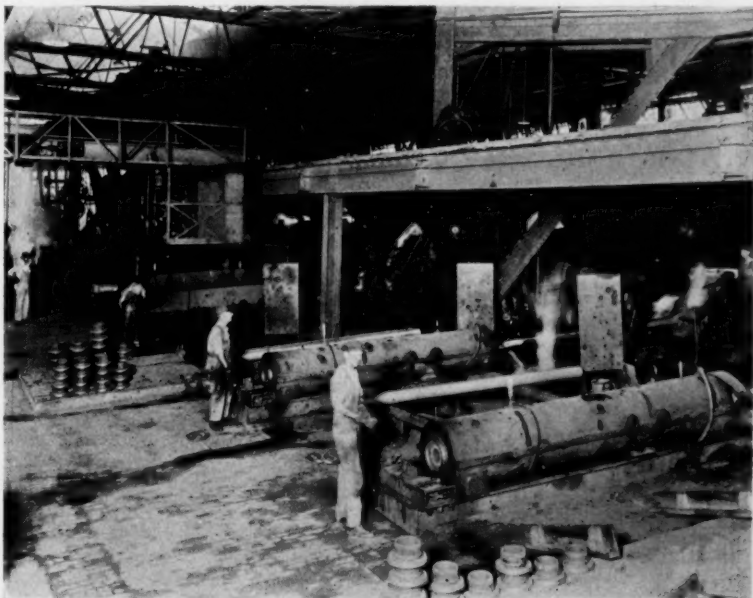


FIG. 4. MAKING CENTRIFUGAL PIPE

In the centrifugal process, which has been developed within the last few years, and which is illustrated by figure 4, the molten metal is run into a rapidly revolving mould in the far end of which there has first been placed a core of the shape of the inside of the bell end of the pipe. The revolving mould is contained within a drum which can be moved longitudinally, and which provides a jacket for water-cooling the outer surface of the mould.

While the bell end of the pipe is being poured, the drum and mould are so placed that the cantilever pouring spout extends into the mould as far as the bell; and when the bell has been poured, the drum, with

the mould still revolving inside of it, is backed off gradually until the spout has been withdrawn to the spigot end. The pouring then ceases, but the mould continues to revolve for a short time until the metal has solidified. When the pipe is withdrawn from the mould, as shown in figure 5, the process is repeated. The metal of pipe made by the centrifugal process has greater density than the metal of cast pipe and has nearly double the tensile strength. This reduces the weight of metal required for any given head. Up to date, centrifugal pipe is made in sizes from 6-inch to 12-inch.

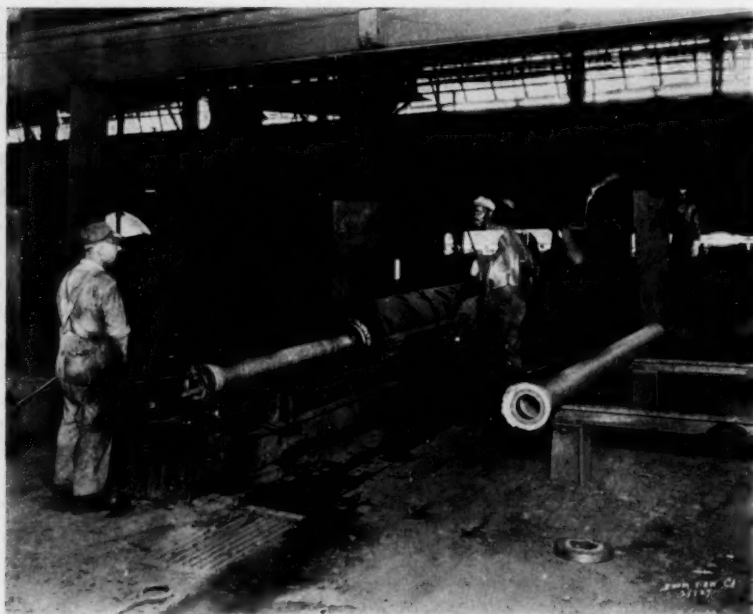


FIG. 5. WITHDRAWING PIPE FROM CENTRIFUGAL MOULD

Steel pipe

In the well known Lock-Bar pipe two plates, the longitudinal edges of which have been slightly upset, are bent to form the two halves of a cylinder. Two bars, each having deep grooves in its sides, are fitted over the adjacent edges of the pair of plates and the sides of the grooves are then squeezed firmly, as shown in figure 6, so as to grasp and hold the upset edges. The longitudinal joint thus formed is considerably stronger than any riveted joint, and

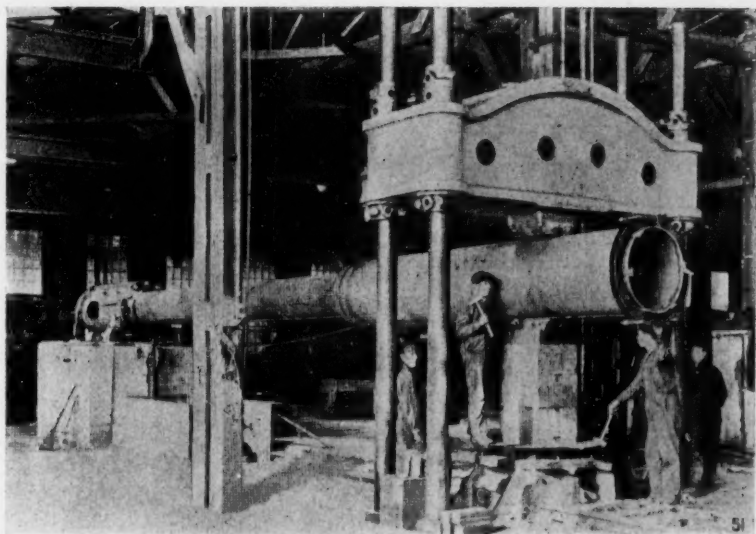


FIG. 6. MAKING LOCK-BAR PIPE

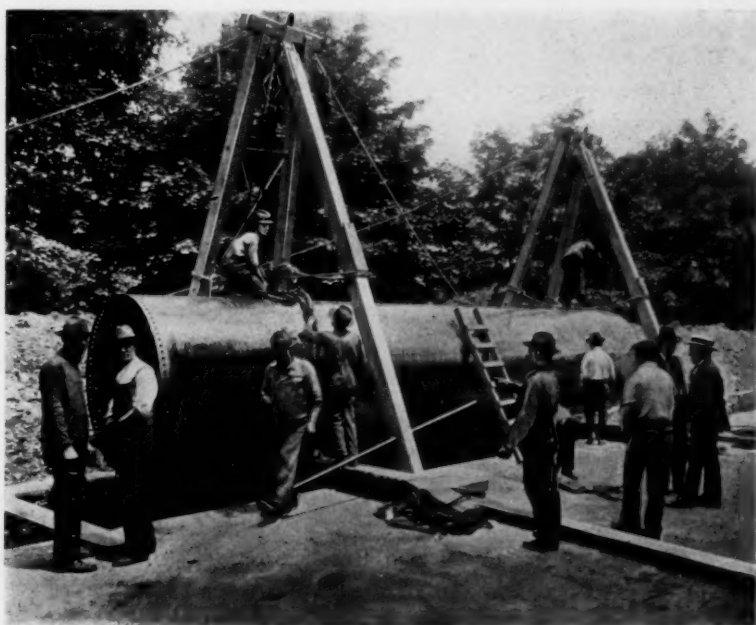


FIG. 7. 72-INCH LOCK-BAR PIPE

somewhat stronger than the average welded joint, the lock-bar joint being actually about as strong as the plate itself. Figure 7 shows a 72-inch pipe of this type being laid in the Catskill Aqueduct System.

The circumferential joints of lock-bar pipe are usually made by tapering each length of pipe slightly and inserting the small end of one pipe into the large end of the next, and riveting the joint, the ends

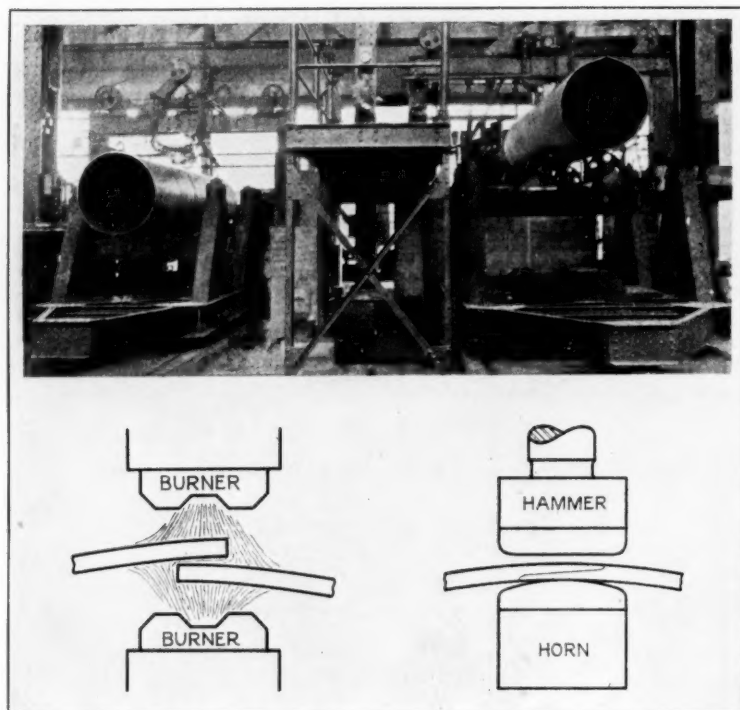


FIG. 8. MAKING HAMMER-WELD PIPE

of the outer portion of each bar being scarfed down under the overlapping plate. Butt-strap joints are also frequently used.

Hammer-weld pipe is made by welding together the two longitudinal edges of one bent plate, or the adjacent longitudinal edges of two or more bent plates, to form the circumferential shell of the pipe. The edges to be welded are lapped, and then heated with gas burners, one above and one below, for a length of 18 inches at a time. The burners are then removed, and before the metal has time to cool,

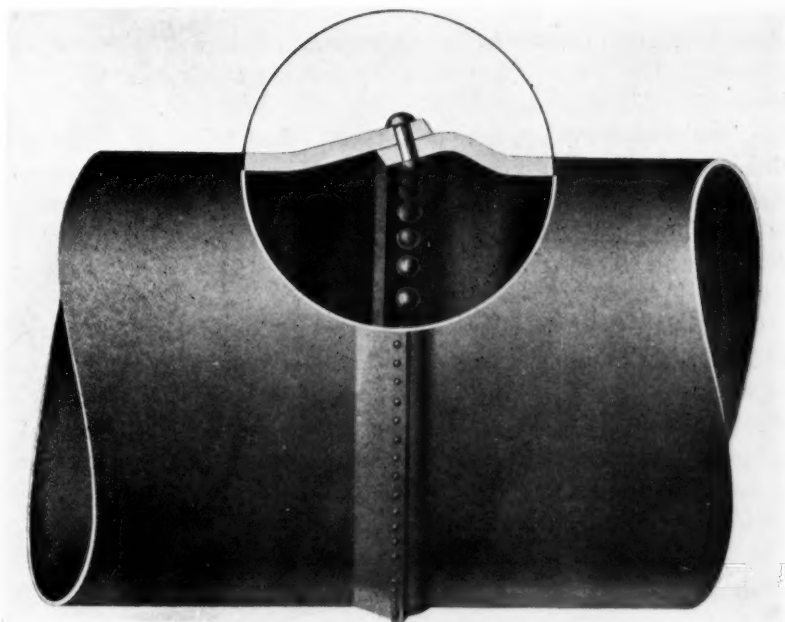


FIG. 9. TAPERED BUMP JOINT

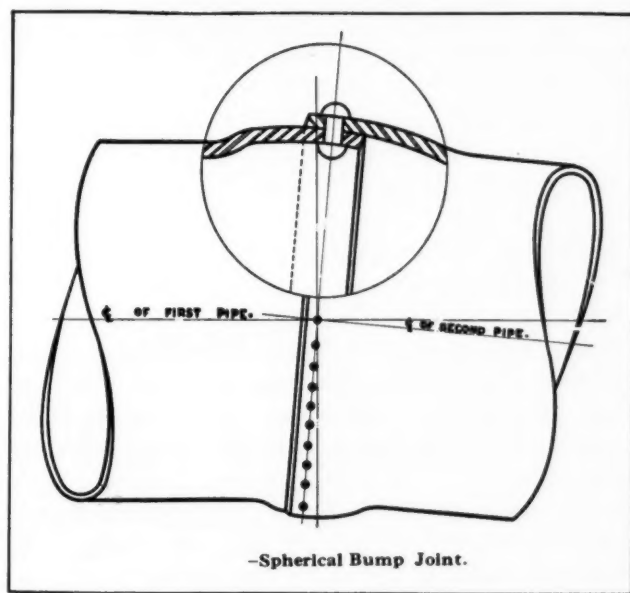


FIG. 10. SPHERICAL BUMP JOINT.

the edges are welded over a horn below them by blows from a hammer above them. The upper half of figure 8 shows two welding machines at work. The lower half shows the gas burners at the left and the hammer and horn at the right.

Figure 9 shows a single riveted tapered bump joint. Figure 10 shows a spherical bump joint, which may be used for angles up to 5 degrees. The rivet holes in the female end of this joint are drilled in the shop, and after the two pipes have been assembled at the desired angle in the trench, these holes serve as a templet for drilling the holes in the male end.

Other joints that may be used with steel pipe include the Mattheson, Dresser, and other types of sleeve or coupling joints; as well as expansion joints, flanged joints, and bell and spigot joints, each of several different types.

Spiral pipes with edges either riveted or crimped together have been in successful use for many years, but principally in sizes of less than 36 inches and where the conditions permit the use of thin shells. The circumferential joints of these pipes are usually either riveted or flanged.

Concrete

Monolithic reinforced concrete pipe has been built in a number of places, generally in very large sizes and under low heads. Theoretically, the construction of monolithic concrete pipe is continuous; actually, it is intermittent, and usually involves circumferential construction joints at short intervals of from 10 to 20 feet. Where the operation of pouring the invert is separate from that of pouring the arch, there are two continuous construction joints along the entire pipe.

No one who has ever built a reservoir with thin walls needs to be told that it is exceedingly difficult to make a construction joint water tight without inserting some sort of metal diaphragm along it. It is also difficult to tamp monolithic pipes thoroughly and to give them as smooth an inner surface as can be obtained with precast pipe tamped between vertical steel forms. Furthermore, the pipe is rigid and has within itself no provision for expansion, contraction, or settlement.

There are many situations in which monolithic pipe, especially in very large sizes, can compete successfully with precast pipe, but the foregoing facts with regard to monolithic pipe should be considered

by anyone who contemplates its use. If these facts are overlooked, disappointment is likely to result.

There are countless makers of reinforced concrete pipe with rigid joints, but, so far as the author has been able to learn, there is only one company which has manufactured and laid on a large scale precast concrete water pipe having joints that will permit, without material leakage, as great a degree of expansion, contraction or settlement for like diameters, as will the lead joints of standard bell and spigot cast iron pipe. In sizes up to 36-inch this pipe is made by the centrifugal process in a manner similar to that described for centrifugal cast iron pipe, and with somewhat similar results, the material in the

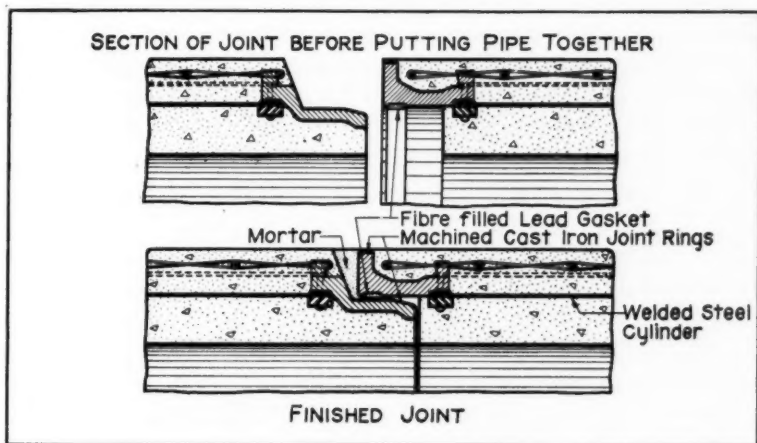


FIG. 11. JOINT OF NORFOLK CYLINDER PIPE

shell of the pipe being much denser and the shell much thinner than in the cast pipe of like diameter and designed for the same heads. From 36 inches up to 108 inches, reinforced concrete pipe is now cast between vertical steel forms. Centrifugal concrete pipe is made for heads up to 200 feet; and the cast concrete pipe with bar and mesh reinforcement and without the steel cylinder, is made for heads up to 150 feet. Under greater heads water would seep through the thin concrete walls, and to prevent this, welded cylinders of thin steel plate are inserted between the forms in which the pipe is cast, thus providing a water tight diaphragm with concrete on both sides. In the design of the pipe this thin steel plate is not counted as part of the reinforcement.

The pipe last described is called "Cylinder Pipe" and was first installed about three years ago for part of the line from Lake Prince to Norfolk, Virginia. Figure 11 is a cross-section of the type of joint used in the Norfolk pipe line just mentioned, and shows the shape of the lead gasket before and after the two pipes are pulled together in the trench. Figure 12 shows the type of joint used in the 60-inch and 54-inch pipe lines now being built for Tulsa, Oklahoma, and in the 54-inch pipe line under construction for Denver. In this joint the lead gasket is inserted as the pipe is laid, and is then driven only partly home by caulking from the inside. After the backfilling is completed and the pipe has had time to settle to its final position, caulkers enter the pipe and drive the gasket solidly home, after which the filler-ring of cement mortar is plastered against the gasket. Any internal water pressure which may reach the gasket tends to tighten the joint instead of blowing it out.

Figure 13 shows part of the pipe making plant for the Tulsa line, with the cages of bar reinforcement in the right center of the picture, and the cages of mesh reinforcement connected to the male and female end rings in the left foreground.

Figure 14 shows the placing of the cages of reinforcement around the inner steel forms.

Figure 15 shows the double gantry crane used for pouring the pipe and for handling the pipe and the forms; the rows of pipes and forms; and the pipe racks for storing and curing the pipe. As soon as each pipe is poured it is covered with a tarpaulin and cured for two days in wet steam at about 100 degrees Fahrenheit. It can then safely be picked up by the gantry and laid on the pipe rack, where it is cured for ten days longer before being loaded on cars for transportation to the trench.

In figure 16 are shown a number of cast iron bases for the steel forms. The pipe with the steel band around its middle is ready to be picked up and laid on the pipe rack.

Wood stave

The staves of wood stave pipe are so milled that their outer and inner surfaces conform to the outer and inner cylindrical surfaces of the pipe. The abutting edges of each stave are radial plane surfaces except that there is a small triangular tongue along one radial edge, and a corresponding small triangular groove along the other edge to receive the tongue of the adjacent stave. The

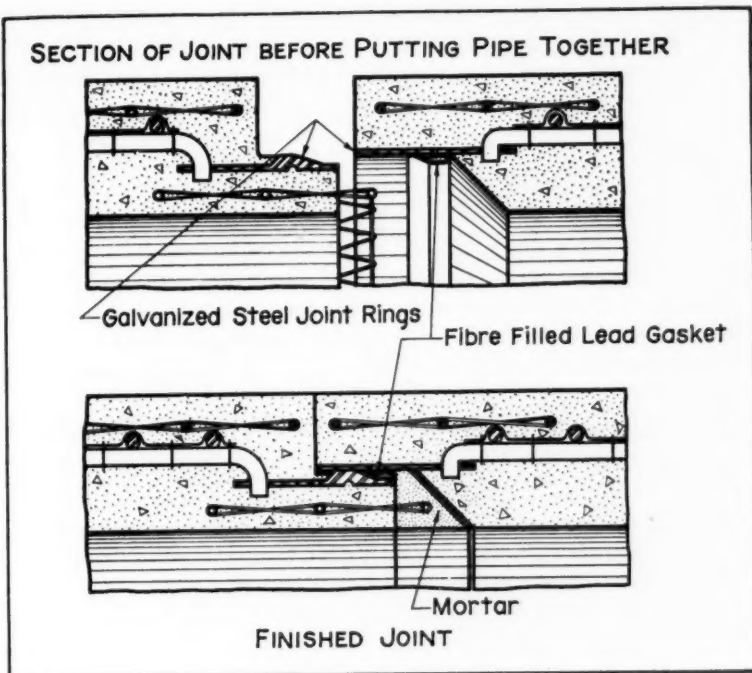


FIG. 12. JOINT OF PIPE FOR TULSA



FIG. 13. PART OF PIPE MAKING PLANT, TULSA



FIG. 14. PLACING REINFORCEMENT, TULSA



FIG. 15. FORMS, PIPE RACKS AND CRANE, TULSA



FIG. 16. CAST IRON BASES FOR FORMS, TULSA



FIG. 17. WOOD STAVE PIPE, NORFOLK

makers of pine pipe have two such tongues and grooves in the edges of their staves, which are thicker than the staves used in the Pacific Coast pipe. These tongues and grooves insure a smoother and more truly cylindrical inner surface by preventing any one stave from projecting further down into the pipe than its neighbors on either side of it. The tongue and groove also tend to prevent leakage at the longitudinal joints between staves.

Continuous stave pipe is built up progressively in the trench, the staves, bands, shoes and tongues being shipped unassembled. The staves come in random lengths. They have no tenons, but are cut off square at the ends, the joints between stave ends being made water tight by small steel tongues fitting into saw-kerfs in the abutting ends. The staves are held together by steel bands, the diameter and spacing of which are determined by the diameter of the pipe and by the internal pressures which they are called upon to resist.

A portion of the Norfolk wood stave line is shown in figure 17.

Wood stave pipe when once laid should be kept always full of water under pressure. Unless there can be some reasonable assurance that it will not be frequently subjected to alternations of wetness and dryness, wood stave pipe should not be laid except to meet a temporary emergency. If the staves be allowed to dry out, the pipe is sure to leak, for a time at least, as soon as it is re-filled; and if they be subjected to frequent alternations of wetness and dryness, the staves will rot.

To keep the pipe just full of water, but not under pressure, will not be sufficient to protect the staves from decay, as a certain amount of pressure is required to force the water into the staves and saturate them thoroughly; and a permanently saturated condition is the thing which conduces most to the longevity of the staves. For this reason it is desirable not to lay any portion of a wood stave line within less than 30 feet of the hydraulic gradient.

The staves should be thoroughly seasoned and dried, and should be absolutely free from knots and sap wood. In its freedom from knots and sap, as well as in its durability, redwood, in the author's opinion, is superior to fir.

General

If the best results are to be obtained from any of the pipes here-discussed, care, intelligence and the knowledge born of experience

should be exercised in installing them in the field. Careful surveys and test borings to determine the best location of the line will undoubtedly always pay for themselves. The final location should only be selected after a thorough study of its effect on the hydraulic gradient of the line, and of the nature of the difficulties encountered,—such as rock excavation, abnormally wet soils, river, creek and railway crossings; and other things which would tend to increase the cost of the work. In some parts of this country soils containing alkali have been known to cause serious and rapid injury to concrete, steel, and cast iron pipes, and to the bands, and even to the staves, of wood stave pipe. The soil of salt marshes will corrode iron and steel rapidly. Where there is any danger of the existence of these conditions, analyses should be made to determine whether the soil contains injurious chemical constituents.

Great care should be taken to provide a firm and uniform foundation for the pipe, no matter what may be its material, as settlement is bad for any pipe. By far the larger part of the breaks which have occurred in cast iron pipe have been due to settlement rather than to internal pressure. All bends should be firmly braced. The materials for backfilling under and around the pipe should be carefully selected, and should be so compacted as to prevent unequal external pressures. These unequal pressures are much less dangerous to cast iron and concrete pipes than to steel and wood stave pipes.

In order to prevent the formation of a vacuum in the pipe, an air valve of ample size should be set at every important summit on the line. This valve should be of a type which will admit air freely and promptly when the internal pressure is removed, and which will remain open and allow air to pass out freely as the pipe is refilled, closing automatically as soon as the pipe beneath it is full of water. The danger of injury to the line as the result of the sudden formation of a vacuum in it would be very much greater in the case of steel or wood stave pipes than in the case of concrete or cast iron pipes. Air pockets at summits will reduce the carrying capacity of any pipe line and will frequently cause objectionable water ram; and air valves properly placed will keep these pockets from forming. In the case of wood stave pipe, the existence of air pockets will be very injurious to the staves, as it will make them alternately wet and dry, thus accelerating their decay.

The installation of gate valves on a large water supply main is a matter which deserves careful consideration. Gate valves are usually inserted for the purpose of isolating one section of the line in order that it may be drained for repairs; but in the author's opinion there are many cases in which no gate valves should be placed in any part of the line except at its upper end. The closing of a gate valve may increase the pressure back of it beyond that for which the pipe is designed; and unless there is an ample air inlet in the pipe immediately beyond the gate valve, the closing of the gate may also cause an injurious vacuum to be formed in the pipe beyond it. Furthermore, large gate valves are very expensive.

In many cases it is wise to install overflow openings of the full capacity of the pipe on at least a few of the more important summits. These overflows should be carried up to the hydraulic gradient, and they should be capable of admitting air rapidly, as well as of providing for the overflow of water. They should be so built as to make it impossible for birds to enter the pipe or for anyone to put any injurious substance into it, and they should contain provision for the insertion of a bulkhead across the pipe. These bulkheads will enable the overflows to be used as test towers for determining by actual measurement the leakage in the portion of the line lying between any two of them.

There will be about ten of these combination overflows, air inlets and test towers on the 28 miles of 60-inch and 24 miles of 54-inch concrete pipe now under construction for the City of Tulsa.

It is also a good plan to provide plenty of manholes in any line which is large enough for a man to enter.

Divided responsibility on any work almost invariably leads to trouble, and it is therefore desirable to have all of the work connected with any pipe line done by one contractor. The makers of cast iron and steel pipe will not contract to do more than furnish their own products, and all of the field work must be done either by the purchaser or by a contractor acting as his agent. In the case of these two pipes this condition is not so objectionable as it has been found to be in the case of concrete and wood stave conduits, where the pipe maker lays his own pipe, and guarantees its perfection. If the transportation, excavation, backfilling and tamping be done by any other party, trouble may be expected. Wherever possible all of this work should be done by the contractor who furnishes the pipe.

FIRST COST

The estimates of first cost herein presented are approximate only, as they are necessarily based on certain assumed conditions which might not obtain in any given case.

They are limited to one type of pipe in each of the four materials, this being done not with the intention of indicating a preference for the types considered, but because the time required for estimates on every available type would be out of all proportion to the value of the estimates.

The precast concrete pipe discussed is patented; but it is believed that there are patents on one or more details, either of design or manufacture, in the case of practically every other pipe considered. In any event, competition between a number of available types could be secured by a properly worded advertisement of the letting.

In each of the estimates deliveries of material are supposed to be f.o.b. cars, with Chicago freight allowed.

Prices of materials are those of January 1, 1924, and common labor is taken at 50 cents an hour. Trenches are assumed to have a clear width 2 feet greater than the outside diameter of the pipe, and to be deep enough to provide 2 feet of cover. In each case the length of the line is assumed to be 25 miles, and the average haul from cars to trench is assumed to be half of this length, or $12\frac{1}{2}$ miles. Where the weight of a single pipe is less than 3 tons, the hauling is assumed to be done by truck. For pipe of greater weight, the cost of constructing and operating a temporary railroad is included in the item of hauling. Each item includes contractor's profit.

Cast iron

Table 1 shows the estimates of first cost of standard bell and spigot cast iron pipe of various diameters and for various heads. In further explanation it may be said that the item of 15 per cent in column 6 is intended to cover all unusual difficulties, such as deep or wet trenches; rock excavation; river, creek and railway crossings; valves, fittings, manholes, air valves and drains; and engineering plans and supervision.

Steel pipe

Table 2 shows the estimated first cost of hammer-weld steel pipe. Column 6 in this table covers the same items as in table 1.

TABLE 1
Cast iron pipe
 Costs per linear foot

INSIDE DIAMETER	(1) CAST IRON PIPE F.O.B. CHICAGO	(2) HAULING	(3) TRENCH- ING AND BACK- FILLING	(4) LEAD YARN AND LAYING	(5) SUM OF COLUMNS 1, 2, 3 AND 4	(6) APPROX- IMATE, UNUSUAL, DIFFICULTIES AND ENGINEERING	(7) TOTAL COST COLUMN 5 AND COLUMN 6
50 and 100 foot head (Class A)							
<i>inches</i>							
20	\$4.55	\$0.50	\$0.60	\$0.47	\$6.12	\$0.92	\$7.04
24	6.19	0.57	0.70	0.57	8.03	1.20	9.23
30	8.86	0.78	0.88	0.71	11.23	1.68	12.91
36	11.90	1.02	1.06	0.87	14.85	2.23	17.08
42	15.54	1.20	1.28	1.00	19.02	2.85	21.87
48	20.24	1.30	1.53	1.18	24.25	3.64	27.89
54	24.28	1.80	1.76	1.35	29.19	4.38	33.57
60	27.83	2.00	2.02	1.52	33.37	5.01	38.38
72	38.94	2.40	2.61	1.84	45.79	6.87	52.66
150 and 200 foot head (Class B)							
20	4.87	0.56	0.60	0.47	6.50	0.98	7.48
24	6.49	0.66	0.70	0.57	8.42	1.26	9.68
30	9.27	0.87	0.88	0.71	11.73	1.76	13.49
36	12.64	1.15	1.06	0.87	15.72	2.36	18.08
42	16.49	1.25	1.28	1.00	20.02	3.00	23.02
48	20.89	1.60	1.53	1.18	25.20	3.78	28.98
54	25.98	2.00	1.76	1.35	31.09	4.66	35.75
60	30.75	2.30	2.02	1.52	36.59	5.49	42.08
72	43.06	2.80	2.61	1.84	50.31	7.55	57.86
250 foot head (Class C)							
20	5.79	0.60	0.60	0.47	7.46	1.19	8.65
24	7.77	0.76	0.70	0.57	9.80	1.47	11.27
30	11.14	1.04	0.88	0.71	13.77	2.07	15.84
36	15.21	1.30	1.06	0.87	18.44	2.77	21.21
42	19.97	1.40	1.28	1.00	23.65	3.55	27.20
48	25.29	1.95	1.53	1.18	29.95	4.49	34.44
54	31.78	2.15	1.76	1.35	37.04	5.56	42.60
60	37.35	2.50	2.02	1.52	43.39	6.51	49.90
72	53.03	3.30	2.61	1.84	60.78	9.12	69.90

TABLE 2
Steel pipe
 Costs per linear foot

INSIDE DIAM- ETER	THICK- NESS	(1) PIPE F.O.B. CHICAGO	(2) HAULING	(3) TRENCH- ING AND BACK- FILLING	(4) LAYING	(5) SUM OF COLUMNS 1, 2, 3 AND 4	(6) APPUR- TENANCES, UNUSUAL DIFFICUL- TIES AND ENGI- NEERING	(7) TOTAL COST COLUMN 5 AND COLUMN 6
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50 to 150 foot head

inches	inches							
20	$\frac{1}{4}$	\$4.26	\$0.20	\$0.51	\$0.25	\$5.22	\$0.78	\$6.00
24	$\frac{5}{16}$	6.39	0.25	0.59	0.27	7.50	1.12	8.62
30	$\frac{3}{8}$	8.07	0.33	0.74	0.30	9.44	1.42	10.86
36	$\frac{3}{8}$	11.74	0.45	0.94	0.33	13.46	2.02	15.48
42	$\frac{3}{8}$	14.11	0.50	1.17	0.36	16.14	2.42	18.56
48	$\frac{3}{8}$	16.23	0.55	1.37	0.40	18.55	2.78	21.33
54	$\frac{7}{16}$	21.17	0.73	1.58	0.50	23.98	3.60	27.58
60	$\frac{7}{16}$	23.68	0.80	1.83	0.60	26.91	4.04	30.95
72	$\frac{1}{2}$	34.86	1.00	2.34	0.70	38.90	5.84	44.74

200 foot head

20	$\frac{1}{4}$	4.26	0.20	0.51	0.25	5.22	0.78	6.00
24	$\frac{5}{16}$	6.39	0.25	0.59	0.27	7.50	1.12	8.62
30	$\frac{3}{8}$	8.07	0.33	0.74	0.30	9.44	1.42	10.86
36	$\frac{3}{8}$	11.74	0.45	0.94	0.33	13.46	2.02	15.48
42	$\frac{3}{8}$	14.11	0.50	1.17	0.36	16.14	2.42	18.56
48	$\frac{7}{16}$	18.82	0.65	1.37	0.40	21.24	3.19	24.43
54	$\frac{7}{16}$	21.17	0.73	1.58	0.50	23.98	3.60	27.58
60	$\frac{1}{2}$	26.81	0.85	1.83	0.60	30.09	4.51	34.60
72	$\frac{1}{2}$	34.86	1.00	2.34	0.70	38.90	5.84	44.74

250 foot head

20	$\frac{1}{4}$	4.26	0.20	0.51	0.25	5.22	0.78	6.00
24	$\frac{5}{16}$	6.39	0.25	0.59	0.27	7.50	1.12	8.62
30	$\frac{3}{8}$	8.07	0.33	0.74	0.30	9.44	1.42	10.86
36	$\frac{3}{8}$	11.74	0.45	0.94	0.33	13.46	2.02	15.48
42	$\frac{7}{16}$	16.31	0.55	1.17	0.36	18.39	2.76	21.15
48	$\frac{1}{2}$	21.32	0.75	1.37	0.40	23.84	3.58	27.42
54	$\frac{1}{2}$	24.23	0.80	1.58	0.50	27.11	4.07	31.18
60	$\frac{1}{2}$	26.81	0.85	1.83	0.60	30.09	4.51	34.60
72	$\frac{1}{2}$	34.86	1.00	2.34	0.70	38.90	5.84	44.74

TABLE 3
Concrete pipe
 Costs per linear foot

INSIDE DIAMETER	(1) PIPE AND LAYING	(2) HAULING	(3) TRENCHING AND BACK- FILLING	(4) SUM OF COLUMNS 1, 2 AND 3	(5) APPUR- TENANCES, UNUSUAL DIFFICULTIES AND ENGINEERING	(6) TOTAL COST COLUMN 4 AND COLUMN 5
50 foot head						
<i>inches</i>						
20	\$3.53	\$0.70	\$0.58	\$4.81	\$0.72	\$5.53
24	4.70	0.75	0.68	6.13	0.92	7.05
30	6.37	0.85	0.84	8.06	1.21	9.27
36	7.84	1.00	1.01	9.85	1.48	11.33
42	9.70	1.62	1.37	12.69	1.90	14.59
48	11.76	1.90	1.63	15.29	2.29	17.58
54	13.20	2.11	1.83	17.14	2.57	19.71
60	14.70	2.25	2.13	19.08	2.86	21.94
72	19.11	2.80	2.70	24.61	3.69	28.30
100 foot head						
20	3.67	0.70	0.58	4.95	0.74	5.69
24	4.90	0.75	0.68	6.33	0.95	7.28
30	6.87	0.85	0.84	8.56	1.28	9.84
36	8.33	1.00	1.01	10.34	1.55	11.89
42	10.55	1.62	1.37	13.54	2.03	15.57
48	13.23	1.90	1.63	16.76	2.51	19.27
54	15.00	2.11	1.83	18.94	2.84	21.88
60	16.91	2.25	2.13	21.29	3.19	24.48
72	22.05	2.80	2.70	27.55	4.13	31.68
150 foot head						
20	4.17	0.70	0.58	5.45	0.82	6.27
24	5.39	0.75	0.68	6.82	1.02	7.84
30	7.55	0.85	0.84	9.24	1.39	10.63
36	9.31	1.00	1.01	11.32	1.70	13.02
42	12.50	1.62	1.37	15.49	2.32	17.81
48	16.07	1.90	1.63	19.60	2.94	22.54
54	18.10	2.11	1.83	22.04	3.30	25.34
60	20.58	2.25	2.13	24.96	3.74	28.70
72	25.97	2.80	2.70	31.47	4.72	36.19

TABLE 3—Continued

INSIDE DIAMETER	(1) PIPE AND LAYING	(2) HAULING	(3) TRENCHING AND BACK- FILLING	(4) SUM OF COLUMNS 1, 2 AND 3	(5) APPUR- TENANCES, UNUSUAL DIFFICULTIES AND ENGINEERING	(6) TOTAL COST COLUMN 4 AND COLUMN 5
200 foot head						
<i>inches</i>						
20	\$4.51	\$0.70	\$0.58	\$ 5.79	\$0.87	\$ 6.66
24	5.83	0.75	0.68	7.26	1.09	8.35
30	8.04	0.85	0.84	9.73	1.46	11.19
36	10.29	1.00	1.01	12.30	1.84	14.14
42	13.20	1.62	1.37	16.19	2.43	18.62
48	16.66	1.90	1.63	20.19	3.03	23.22
54	19.05	2.11	1.83	22.99	3.44	26.43
60	21.81	2.25	2.13	26.19	3.93	30.12
72	27.19	2.80	2.70	32.69	4.90	37.59
250 foot head						
20	5.50	0.80	0.68	6.98	1.05	8.03
24	7.00	0.88	0.77	8.65	1.30	9.95
30	9.75	1.00	0.95	11.70	1.76	13.46
36	12.49	1.30	1.13	14.92	2.24	17.16
42	14.90	1.62	1.37	17.89	2.68	20.57
48	17.64	1.90	1.63	21.17	3.18	24.35
54	20.15	2.11	1.83	24.09	3.61	27.70
60	23.03	2.25	2.13	27.41	4.11	31.52
72	28.42	2.80	2.70	33.92	5.09	39.01

The author is aware that the thicknesses of shell which he has assumed are considerably greater than would be called for by the stresses due to internal pressure. The extra metal is included in order to allow something for corrosion and to provide a stiffer pipe. Other engineers might prefer to use thinner shells with a corresponding decrease in first cost. Close competition with hammer-weld pipe might be expected from lock-bar pipe, riveted pipe, and, in small sizes, from spiral pipe.

Concrete

Table 3 gives estimates of the cost of lock joint reinforced concrete pipe. Column 1 contains quotations from the makers for the pipe delivered f.o.b. cars Chicago, plus the laying of the pipe

TABLE 4
Continuous stave redwood pipe
 Costs per linear foot

INSIDE DIAMETER	(1) PIPE AND LAYING	(2) HAULING	(3) TRENCHING AND BACK- FILLING	(4) SUM OF COLUMNS 1, 2 AND 3	(5) APPUR- TENANCES, UNUSUAL DIFFICULTIES AND ENGINEERING	(6) TOTAL COST COLUMN 4 AND COLUMN 5
50 foot head						
<i>inches</i>						
20	\$2.34	\$0.07	\$0.60	\$3.01	\$0.45	\$3.46
24	2.80	0.09	0.70	3.59	0.54	4.13
30	3.45	0.11	0.88	4.44	0.67	5.11
36	4.12	0.14	1.06	5.32	0.80	6.12
42	4.96	0.16	1.28	6.40	0.96	7.36
48	5.70	0.19	1.53	7.42	1.11	8.53
54	8.50	0.30	1.76	10.56	1.58	12.14
60	9.61	0.34	2.02	11.97	1.80	13.77
72	13.55	0.48	2.61	16.64	2.50	19.14
100 foot head						
20	2.76	0.08	0.60	3.44	0.52	3.96
24	3.31	0.10	0.70	4.11	0.62	4.73
30	4.16	0.14	0.88	5.18	0.78	5.96
36	5.09	0.17	1.06	6.32	0.95	7.27
42	6.25	0.21	1.28	7.74	1.16	8.90
48	7.36	0.26	1.53	9.15	1.37	10.52
54	10.75	0.38	1.76	12.89	1.93	14.82
60	12.34	0.44	2.02	14.80	2.22	17.02
72	17.70	0.63	2.61	20.94	3.14	24.08
150 foot head						
20	3.20	0.10	0.60	3.90	0.58	4.48
24	3.86	0.12	0.70	4.68	0.70	5.38
30	4.91	0.16	0.88	5.95	0.89	6.84
36	6.10	0.21	1.06	7.37	1.10	8.47
42	7.56	0.26	1.28	9.10	1.36	10.46
48	9.09	0.32	1.53	10.94	1.64	12.58
54	13.19	0.47	1.76	15.42	2.31	17.73
60	15.19	0.55	2.02	17.76	2.66	20.42
72	21.85	0.78	2.61	25.24	3.79	29.03

TABLE 4—Continued

INSIDE DIAMETER	(1) PIPE AND LAYING	(2) HAULING	(3) TRENCHING AND BACK- FILLING	(4) SUM OF COLUMNS 1, 2 AND 3	(5) APPUR- TENANCES, UNUSUAL DIFFICULTIES AND ENGINEERING	(6) TOTAL COST COLUMN 4 AND COLUMN 5
200 foot head						
<i>inches</i>						
20	3.66	0.11	0.60	4.37	0.66	5.03
24	4.40	0.14	0.70	5.24	0.79	6.03
30	5.69	0.19	0.88	6.76	1.01	7.77
36	7.16	0.25	1.06	8.47	1.27	9.74
42	8.89	0.31	1.28	10.48	1.57	12.05
48	11.90	0.43	1.53	13.86	2.08	15.94
54	15.60	0.56	1.76	17.92	2.69	20.61
60	19.56	0.70	2.02	22.28	3.34	25.62
72	28.75	1.07	2.61	32.43	4.86	37.29
250 foot head						
20	4.15	0.12	0.60	4.87	0.73	5.60
24	4.90	0.15	0.70	5.75	0.86	6.61
30	7.36	0.25	0.88	8.49	1.27	9.76
36	8.97	0.32	1.06	10.35	1.55	11.90
42	11.04	0.40	1.28	12.72	1.91	14.63
48	13.60	0.49	1.53	15.62	2.34	17.96
54	19.62	0.69	1.76	22.07	3.31	25.38
60	22.46	0.80	2.02	25.28	3.79	29.07
72	32.79	1.22	2.61	36.62	5.49	42.11

in the trench. The figures in table 3 for diameters of from 20-inch to 36-inch, inclusive, and for heads up to and including 200 feet, are for centrifugal pipe. From 42-inch to 72-inch, inclusive, and for heads up to and including 100 feet, the figures are for pre-cast concrete pipe without any steel cylinder. All other figures given are for cylinder pipe, but it should be noted that the figures for pipes less than 36-inch in diameter, and for 250 foot head, have been interpolated by the author, no quotations having been received for these pipes. Competition in concrete pipe would come from monolithic concrete pipe, for which the engineer would have to prepare his own designs and make his own estimates; and probably also from some of the makers of other types of precast concrete pipe. The figures in column 5 include 15 per cent for the same items already enumerated for column 6 in tables 1 and 2.

Wood stave

The quotations presented in column 1 of table 4 are from the Redwood Manufacturers Company, and include the delivery of all pipe materials with Chicago freight allowed, and the assembling and laying of the pipe in the trench. All prices are for continuous stave pipe, although machine banded pipe would be available in diameters of from 2-inch up to 24-inch. Column 5 in table 4 covers items similar to those covered in column 5 of table 3, and in column 6 of tables 1 and 2.

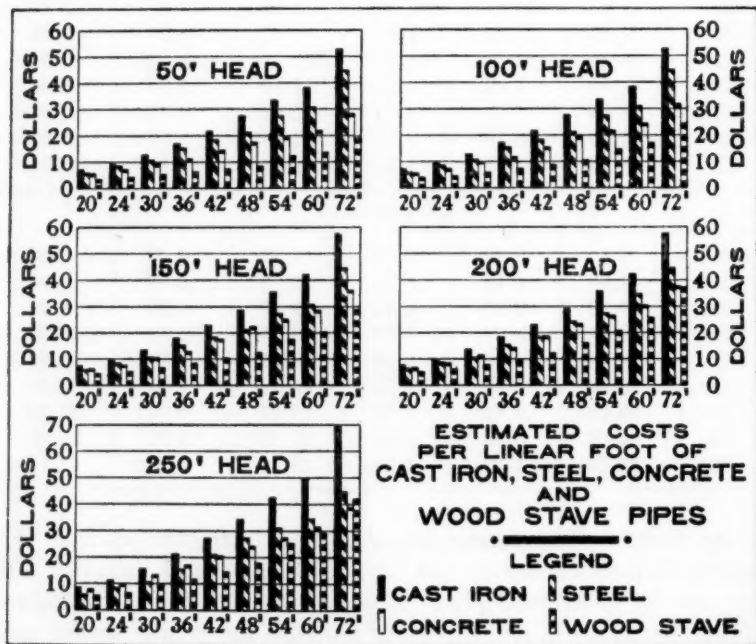


FIG. 18. DIAGRAM SHOWING SUMMARY OF PIPE COSTS

Competitive bids for wood stave pipe built of redwood or fir might be received from the Pacific Tank & Pipe Company, the Continental Pipe Company, and the American Wood Pipe Company, all of the Pacific Coast; and on pipe with white pine staves from the Michigan Pipe Company of Bay City, Michigan, and A. Wyckoff and Son Company of Elmira, New York, the latter firm being apparently more interested in machine banded pipe than in continuous stave pipe.

A summary of the respective costs per linear foot, estimated as above explained, is presented in table 5, and the diagrams in figure 18 were prepared to illustrate this summary.

TABLE 5
Summary of costs per linear foot

SIZE inches	50 FOOT HEAD				100 FOOT HEAD			
	Cast iron	Steel	Concrete	Wood stave	Cast iron	Steel	Concrete	Wood stave
20	\$7.04	\$6.00	\$5.53	\$3.46	\$7.04	\$6.00	\$5.69	\$3.96
24	9.23	8.62	7.05	4.13	9.23	8.62	7.28	4.73
30	12.91	10.86	9.27	5.11	12.91	10.86	9.84	5.96
36	17.08	15.48	11.33	6.12	17.08	15.48	11.89	7.27
42	21.87	18.56	14.59	7.36	21.87	18.56	15.57	8.90
48	27.89	21.33	17.58	8.53	27.89	21.33	19.27	10.52
54	33.57	27.58	19.71	12.14	33.57	27.58	21.88	14.82
60	38.38	30.95	21.94	13.77	38.38	30.95	24.48	17.02
72	52.66	44.74	28.30	19.14	52.66	44.74	31.68	24.08
150 FOOT HEAD					200 FOOT HEAD			
20	\$7.48	\$6.00	\$6.27	\$4.48	\$7.48	\$6.00	\$6.66	\$5.03
24	9.68	8.62	7.84	5.38	9.68	8.62	8.35	6.03
30	13.49	10.86	10.63	6.84	13.49	10.86	11.19	7.77
36	18.08	15.48	13.02	8.47	18.08	15.48	14.14	9.74
42	23.02	18.56	17.81	10.46	23.02	18.56	18.62	12.05
48	28.98	21.33	22.54	12.58	28.98	24.43	23.22	15.94
54	35.75	27.58	25.34	17.73	35.75	27.58	26.43	20.61
60	42.08	30.95	28.70	20.42	42.08	34.60	30.12	25.62
72	57.86	44.74	36.19	29.03	57.86	44.74	37.59	37.29
250 FOOT HEAD								
20	\$8.65	\$6.00	\$8.03	\$5.60				
24	11.27	8.62	9.95	6.61				
30	15.84	10.86	13.46	9.76				
36	21.21	15.48	17.16	11.90				
42	27.20	21.15	20.57	14.63				
48	34.44	27.42	24.35	17.96				
54	42.60	31.18	27.70	25.38				
60	49.90	34.60	31.52	29.07				
72	69.90	44.74	39.01	42.11				

PHYSICAL COMPARISON

It will next be in order to discuss the physical advantages or disadvantages of the four types of pipe whose construction costs have

been estimated, and to endeavor to put values on these advantages or disadvantages, to the end that when proper allowances shall have been made for these values, the pipes may be compared strictly on a dollar-and-cent basis.

In what follows no attempt will be made to compute the values of these advantages for each size of pipe and for each different head, but one method of computing these values and allowing for them will be illustrated by an example in which certain conditions will be assumed to exist. The engineer charged with the design of any supply line can substitute for the conditions assumed in the example cited, the actual conditions in the case in which he is interested, and can in that way arrive at conclusions which will fit his case.

The most important things to be considered in comparing the four different types of pipe are their carrying capacity, their leakage and their durability.

Carrying capacity

Unfortunately there is a dearth of data with regard to the capacities of some of the pipe under consideration; and there is a possibility of wide variation in the capacities even of lines built of the same material. The excellent tables of Messrs. Williams and Hazen are almost universally accepted for cast iron and steel pipe. These tables, however, wisely recognize the fact that the interior surfaces of cast iron and steel pipe are subject to corrosion and tuberculation, and that the pipes decrease in capacity with age. Cast iron pipe of large size when first laid may be assumed to have a capacity corresponding to a value of from 130 to 140 for the coefficient C in the Hazen-Williams formula. The coefficient C for cast iron pipes conveying swamp water has been known to decrease in value to 70 in a period of six or seven years.

For mains 36-inch and larger, the Hazen-Williams tables give a value of 100 for the coefficient C after the pipe has been in service for twenty years, and for the purposes of this paper this value will be assumed for cast iron pipe. It would probably also be fair to assume similar values for lock-bar and hammer-weld pipe. Riveted steel pipe would probably have 10 or 15 per cent less capacity than hammer-weld or lock-bar pipe.

The best available tests of reinforced concrete and wood stave pipe are those made by Mr. F. C. Scobey and contained in Bulletins 852 and 376 of the United States Department of Agriculture. Mr.

Scobey gives C in the Hazen-Williams formula a value of 140 for reinforced concrete pipe in which the concrete is well spaded against oiled steel forms. For wood stave pipe C is given as about 125.

So far as is known, the inner surfaces of concrete and wood stave pipes are usually not injuriously affected except to the extent of the formation of a very thin layer of slime, but some slight allowance should be made for this slime as well as for sediment that might be deposited in the pipe. With the best type of modern reinforced concrete pipe made over steel forms, it is believed that it would be fair to assume $C = 140$ for the pipe when first laid, and $C = 130$ for the purpose of comparison with the other pipes herein considered. A similar line of reasoning would lead to the assumption of $C = 115$ for the wood stave pipe.

Leakage

Engineers have estimated the leakage in cast iron pipe at all the way from 100 to 500 gallons per twenty-four hours per inch of diameter per mile of pipe. In the writer's opinion no well laid cast iron main ought to leak more than 100 gallons per inch mile.

Steel pipe ought to be about as tight as cast iron. The reinforced concrete pipe line in Norfolk, some of which was cylinder pipe, leaked under official test 83.6 gallons per inch mile, and 5 miles of 54-inch reinforced concrete pipe, installed in 1921 for Denver, showed a test leakage of 90 gallons per inch mile. The writer has tested two wood stave pipe lines, each of which showed a leakage approximating 1000 gallons per inch mile. One of these lines was very badly laid, however, and was far from being the best type of pipe. In the other line most of the leakage apparently came from cast iron fittings which had not been sufficiently braced.

Unofficial tests of the wood stave pipe laid at Norfolk showed that its leakage, which started considerably above 1000 gallons per inch mile, had been reduced to about 300 gallons within a few months, part of the reduction being due to repairs, and part to the swelling of the staves and the silting up of the joints between the ends of the staves.

For the purpose of this comparison, the leakage of the cast iron, steel and reinforced concrete pipes will be assumed at 100 gallons per inch mile each, and that of the wood stave pipe at 350 gallons per inch mile.

Durability

Volumes might be written on this subject alone, but the life of any pipe is affected to so great an extent by conditions which vary greatly that no one could make even an approximate prediction as to the life of a pipe without a most intimate knowledge of the conditions by which it will be surrounded. Even with this intimate knowledge, no one would be justified in claiming to be able to predict its life within 15 per cent. One might, however, be justified in assuming, for purposes of comparison, certain figures for the longevity of the several pipes, with the understanding that these figures are to be considered as relative only and that they are not put forth as representing the actual respective lives of the pipes considered.

The life of the pipe may be terminated, in the case of cast iron and steel, by the corrosion of the metal; in the case of concrete, by the chemical disintegration of the concrete, combined with the corrosion of the steel; and in the case of the wood stave pipe, by the corrosion of the bands or by the rotting of the staves. The life of any of these pipes may also be terminated by the fact that it has become obsolescent or has reached the limit of its useful term of service.

So far as corrosion is concerned, cast iron pipe, unless affected by electrolysis or unless laid in salt marshes or in soil containing a very high percentage of alkali, or unless conveying water of a very injurious character, will last so long that engineers usually assume its life at one hundred years, on the theory that by that time the pipe may have been disposed of by obsolescence or in some other manner, and that by that time also all persons now living will be dead, and it will not matter very much to any one now interested in the problem how much longer the pipe will last.

Opinions differ as to whether steel is corroded more rapidly than cast iron, although the majority of people would give cast iron somewhat greater durability. In the author's opinion, steel pipe of fair thickness laid in good soil, and conveying ordinarily good water, might be in fair condition so far as strength is concerned, at the end of one hundred years; but if the life of the thicker cast iron be taken at one hundred years it would seem fair, for the purposes of comparison only, to put the life of steel pipe at from forty to eighty years, according to the thickness of its shell.

Concrete pipe has not been in use nearly as long as either cast iron or steel pipe, but concrete is generally recognized as a very durable material, and the steel which gives the pipe its strength is imbedded in and protected by the concrete. Figure 19 shows samples of cast iron and of cement lined steel pipe, all of which were cut from water mains in the City of Norfolk, and all of which had been laid in similar soils and under similar conditions for more than 20 years prior to the time when they were removed from the ground. The outside of the cast iron pipe showed little or no corrosion. Its interior surface, however, had been very seriously corroded by the organic acids in the swamp water conveyed by the

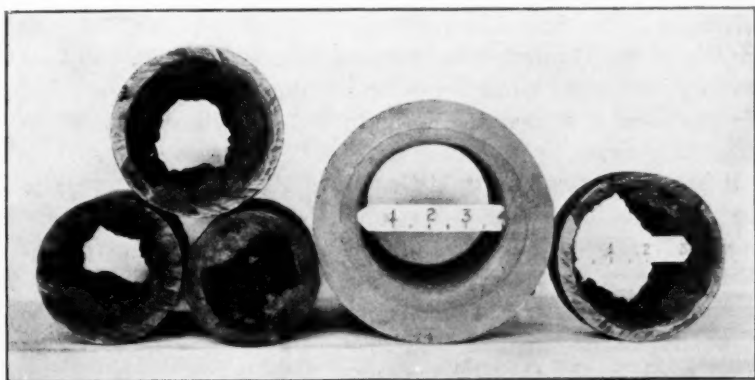


FIG. 19. CAST IRON AND CEMENT LINED PIPE, NORFOLK

pipes. In places this corrosion extended half way from the inner to the outer surface of the pipe, and the metal dissolved by these acids was redeposited in the tubercles shown in the picture.

The concrete pipe shown consisted of an inner lining of one-half-inch of cement mortar, a thin riveted diaphragm of No. 20 gauge steel, then a thickness of $\frac{5}{8}$ inch of cement mortar, and finally an outer shell of No. 28 gauge steel.

The outer steel shell showed some corrosion, but the 20-gauge steel diaphragm between the two layers of cement mortar was absolutely as good as the day the pipe was built, and showed no corrosion of any kind, notwithstanding the fact that when the cement was broken away from it there were drops of moisture on the surface of the thin steel plate.

The theory advanced for the surprisingly good condition of this steel diaphragm was that the presence of the protecting layer of concrete prevented any interchange of the water which first seeped through the mortar to the steel, and consequently any renewal of the dissolving reagents contained in it, and that the acidity of this water was probably neutralized in the first instance by passing through the concrete.

A few decades ago cement lined iron pipe was used quite often, especially in New England, and almost every engineer who has examined this pipe after it had been in the ground for some years has remarked on the excellent state of preservation of the wrought iron or steel diaphragm imbedded in the concrete.

No one knows how long reinforced concrete pipe will last, but if the life of cast iron pipe be assumed at one hundred, and that of steel at from forty to eighty years, it would probably be fair, for the purposes of this comparison, to put the life of concrete pipe at seventy years.

It has sometimes been said that the life of a wood stave pipe is the life of its bands, but this is often far from being the case. If, as already stated, the staves are not kept thoroughly saturated at all times they will decay, no matter whether they are redwood, fir or pine. Furthermore, in certain soils the life of the staves appears to be much shorter than in others. In some of Denver's wood stave conduits the staves have lasted only a few years in certain parts of the line, but are in good condition today, after many years of service, in other parts of the same line. There are, however, many wood stave lines now in existence that are giving first-class service after 25 or 30 years of life, and that will almost certainly continue to give service for many years to come.

The life of the steel bands on wood stave pipe depends on their thickness and on the nature of the soil in which they are buried. In the writer's opinion a continuous stave redwood pipe, if kept full of water under pressure, and laid in ordinarily good soil, may fairly be assumed, for the purposes of comparison, to have a life of forty years.

To sum up, the respective lives of the cast iron, steel, reinforced concrete and wood stave pipes herein considered will be assumed in this paper, and solely for the purposes of the comparison which follows, at 100, 70, 70 and 40 years.

FINANCIAL COMPARISON

It will next be in order to illustrate by an example one method by which allowances, reduced to dollars and cents, can be made for the respective capacities, leakages and durabilities of the four pipes considered.

Some of those allowances will be related to capital charges involving, in some instances, the cost of the entire project, and in others, the cost of portions of the project; and some of them will be related to operating expenses only.

Let us assume that the length of our conduit will be 25 miles, or 132,000 feet; that its diameter will be 54 inches; and that it must be capable of delivering 50 million gallons per 24 hours at its lower end. With $C = 100$ for cast iron and steel pipe, the friction loss for each of these two pipes would be 256 feet; for the concrete pipe, with $C = 130$, the friction loss would be 157 feet; and for the wood stave pipe, with $C = 115$, the friction loss would be 199 feet. In computing the above friction losses, allowance has been made for the small friction loss caused by the water which would leak from each pipe on the way down.

It is next assumed that, if the line be either cast iron or steel, the average head on it would be 150 feet; if concrete, 100 feet; and if wood stave, 122 feet. The difference between these heads for any two pipes is equal to half the difference between the friction losses for the same two pipes.

It is assumed that there will be a dam to form an impounding reservoir at the upper end of the line, and a steam pumping station taking water from the reservoir and forcing it through the pipe. The cost of the dam and pumping station building and immediate piping connections is assumed at \$1,800,000 in the case of each of the four pipe lines; and the cost of the pumps and boilers required is roughly estimated at \$275,000 for either the cast iron or steel pipe, \$200,000 for the concrete pipe and \$235,000 for the wood stave pipe, the differences in the cost of the pumping equipment being due entirely to the differences in the pumping heads.

If the average head on the cast iron, steel and wood stave pipes were 100 feet, as in the case of the concrete pipe, it will be seen from table 5 that the first cost of the cast iron pipe would be \$33.57, of the steel pipe \$27.58, of the concrete pipe \$21.88, and of the

wood stave pipe \$14.82. But the differences in average head increase the cost of cast iron pipe by \$2.18, bringing it up to \$35.75, while the cost of the steel pipe is not increased, as the thickness assumed for 100 foot head is sufficient for 150 foot head. The cost of the concrete pipe remains at \$21.83, which corresponds to a head of 100 feet. The cost of the wood stave pipe, which is designed for an average head of 122 feet, is found by interpolation to be \$16.10, showing an increase of \$1.28.

The total actual investment in each case, including an allowance of 50 cents per linear foot for right-of-way, may now be summarized as follows:

	CAST IRON	STEEL	CONCRETE	WOOD STAVE
Dam, pumping station, piping connections and real estate.....	\$1,800,000	\$1,800,000	\$1,800,000	\$1,800,000
Pumping equipment.....	275,000	275,000	200,000	235,000
Pipe line.....	4,719,000	3,640,560	2,888,160	2,125,200
Right-of-way.....	66,000	66,000	66,000	66,000
Total.....	\$6,860,000	\$5,781,560	\$4,954,160	\$4,226,200

The above summary states the estimated actual cost of the several pipe lines, but it will be noted that the pumping equipment required in the case of the cast iron and steel pipes costs \$75,000 more than that required for the concrete pipe, and that the pumping equipment for the wood stave pipe costs \$35,000 more than that for the concrete pipe. To allow for these differences, we should have to charge the cast iron and steel pipe each with an added cost of 57 cents per linear foot, and the wood stave pipe with an added cost of 27 cents per linear foot, in order to compare them with concrete pipe, on the basis of cost of pumping equipment.

The operating expense for labor would be the same in all four cases; but assuming an average pumpage of 30 million gallons per day, the annual fuel cost at \$5.00 per ton for coal is estimated at \$46,166 per year for cast iron or for steel; \$28,313 for concrete, and \$35,887 for wood stave. The difference between the fuel cost for either the cast iron or steel pipes and for the concrete pipe would be \$17,853, which amount capitalized at 6 per cent would produce \$297,550. Similarly, the difference between the fuel costs for the wood stave pipe and for concrete pipe would be \$7,574 which,

capitalized at 6 per cent, would be \$126,233. We should charge therefore the cast iron and steel pipes with \$297,550 each, and the wood stave pipe with \$126,233, in order to allow for the greater carrying capacity of the concrete pipe. These charges would amount to \$2.25 per linear foot each in the case of the cast iron and steel pipes, and to \$0.96 per linear foot in the case of the wood stave pipe.

We have assumed that the cast iron, steel and concrete pipes would each leak at the rate of 100 gallons in 24 hours per inch of diameter per mile of pipe, and that the leakage in the wood stave line would be 350 gallons per inch mile, so that the wood stave pipe should be charged with the value of 250 gallons per inch mile, in order to put it on the same footing with regard to leakage as the other three pipes. Two hundred and fifty gallons per inch mile would amount to 337,500 gallons per day, which is six hundred and seventy-five one-thousandths of one per cent of the total net capacity of the line.

The cost of the entire project, assuming that wood stave pipe be used, would be \$4,226,200, and applying the percentage just found, we have \$28,527 as the capital charge against the wood stave pipe, on account of its greater leakage. This corresponds to 22 cents per linear foot.

We must next charge the wood stave line with the capitalized cost of pumping 337,500 gallons of water which would never reach the lower end of the pipe line. Estimating the cost of pumping at three-quarters of a cent per 1000 gallons, the annual cost of pumping 337,500 gallons per day would be \$924, which, capitalized at 6 per cent, would equal \$15,400, which is equivalent to 12 cents per linear foot.

We must next allow for the respective durabilities of the four pipes. The actual costs per linear foot of the four pipes would, as already stated, be \$35.75 for cast iron, \$27.58 for steel, \$21.88 for concrete, and \$16.10 for wood stave.

Having assumed the life of cast iron at one hundred years, and that of steel and concrete each at seventy years, it would be necessary to charge each of the two last named pipes with three-sevenths of a renewal, seventy years from date, to put it on a comparable basis with cast iron.

The present worth of three-sevenths of \$27.58, payable seventy years hence, is \$0.76, which must be added to the cost of the steel pipe in order to allow for the greater durability of cast iron pipe.

The present worth of three-sevenths of \$21.88, payable seventy years hence, is \$0.60, and this sum should, for the same reason, be charged against the concrete pipe.

The life of wood stave pipe has been assumed at forty years, and this pipe would require one renewal forty years from now, and one-half of a renewal eighty years from now. The present worth of \$16.10, payable forty years hence, is \$3.35; and the present worth of one-half of \$16.10, payable eighty years hence, is \$0.35; and these two amounts must be charged against wood stave pipe to put it on a comparable basis with cast iron as to durability.

TABLE 6
Financial summary
Costs per linear foot

	CAST IRON	STEEL	CONCRETE	WOOD STAVE
Actual first cost.....	\$35.75	\$27.58	\$21.88	\$16.10
Capacity allowances for cost of pumping equipment.....	0.57	0.57	0.00	0.27
Capacity allowances for cost of pumping.....	2.25	2.25	0.00	0.96
Leakage allowances, based on total in- vestment.....	0.00	0.00	0.00	0.22
Leakage allowances, based on cost of pumping the leakage.....	0.00	0.00	0.00	0.12
Allowance for durability.....	0.00	0.76	0.60	3.70
Total equivalated costs.....	\$38.57	\$31.16	\$22.48	\$21.37

In table 6 all of the foregoing allowances are set forth under the respective actual costs per linear foot, in order to arrive at the respective costs, corrected for the final comparison.

There are other minor points in which the four pipes differ. For example, wood stave pipe, while elastic enough to withstand a good deal of bending without serious injury, is more fragile than any of the other pipes, is easily collapsed by external pressures, and would probably require somewhat more expense for maintenance throughout its actual life. Most of this expense would be for the renewal of staves and bands. Wood stave pipe, if it is to have a long life, should also be kept full of water under pressure, and it may not always be convenient, or even possible, to do this.

Steel pipe resembles wood stave pipe to some extent in its flexibility and in its tendency to collapse, and is somewhat less able to withstand contractions due to temperature. Most of its maintenance costs would probably be for repairing the pits which might be caused by external or internal corrosion. Recent developments in the art of welding would simplify and cheapen these repairs.

Experience with the modern types of concrete pipe herein discussed has not been long enough to justify any definite statements with regard to the nature of the repairs which might be required. Leakage or even fracture might be caused by extreme deflection due to settlement, but the danger of this would appear to be very remote if the pipe were carefully laid in the beginning, and this would be especially true of concrete pipe of the type in which the joint is caulked from the inside after the trench has been tamped and backfilled and the pipe has settled firmly on its bed.

Cast iron pipe, like the concrete pipe, might leak or break as a result of settlement, and, in fact, a very large percentage of all of the fractures of cast iron pipe come from this cause. These fractures are, however, rare, and cast iron pipe, generally speaking, is easy and inexpensive to maintain. It would probably be necessary to drive up the lead in a few joints occasionally.

Most of the points just referred to are, of course, of small significance as compared with the differences in capacity, leakage and durability for which allowances have been made in the foregoing comparisons and estimates. The author would like to emphasize the statement that all of these comparisons and estimates should be considered solely in the light of the premises and assumptions on which they are based.

DISCUSSION

PRESIDENT FULLER:³ This paper by Colonel Maury is, I think, a very substantial contribution to the knowledge which we all want in respect to waterworks practice, and the Association is to be congratulated on having such a splendid paper. Colonel Maury has asked me to say a few words based on my own experience, and I believe I should call attention perhaps first to the thought uppermost in my mind, and that is that there is a question of local suitability and reliability which cannot be expressed very adequately in the number of cents or dollars per lineal foot.

³ Consulting Engineer, New York, N. Y.

It happens that we have had, in connection with our own work, a good deal of experience that has brought us in contact with almost all the different kinds of material for pipe lines. For instance we are now putting in, in Virginia, at Charlottesville and at Staunton, two long lines of mains, in order to bring gravity supplies down to those communities of about 12,000 population each. One of these mains is, I think, an 18-inch line and one a 16-inch. Each of those small cities is spending 600,000 or 700,000 dollars, a lot of money; and we thought there could be no argument there against putting in cast-iron lines. Incidentally, we are having a somewhat unusual experience in regard to our Staunton project, in that the water is to be taken from the forest reserves in the Blue Ridge Mountains in Virginia, and we have run into an injunction seeking to restrain the United States Secretary of Agriculture from giving us a permit, the injunction suit being brought by riparian owners farther down the stream. They have taken testimony, and what the decision will be I do not know.

There were two occasions, one in 1912 and one in 1916, when I went personally with great care over the wood-stave pipe line which had been installed by the city of Lynchburg for its gravity water supply. I was impressed rather favorably with the suitability of the wood-stave pipe line as a result of the experiences which that city had had; and did not recommend any duplication of that wood-stave pipe line other than at the James River crossing and a number of creek crossings where they did have some leaks at intervals and where it was pretty important to be able to correct those leakages more promptly than was at all times possible on account of the inaccessability of the lines at those stream crossings.

At Memphis we are on a cast-iron basis completely. At the new well water supply and new filter plant and pumping station, we have been having water going through for six or seven weeks and we have had there some rather unusual experiences with broken castings. I think that right now the new pumping station is down because we had a break in a 36-inch cast-iron elbow, due to unequal thicknesses of metal, and it made an unfortunate break. Of course, all such things come out in the testing process.

At Kansas City we have figured on a pressure tunnel for taking the water into the city from the new basins; I think it is an 84-inch pressure tunnel. In this case, as in many other projects like our

Philadelphia project, which I am now figuring on as a member of the Water Supply Commission there, when you get up to those very large capacities there is no question but that you have to use concrete structures. I want also to say a word in regard to the 48-inch line which was installed some 4 years ago at Kansas City, the first project that I looked into there. This line was for the purpose of getting water from Quindaro down to the city; and lockjoint concrete pipe, with the particular type of joint used in Tulsa, was put in. I think that line has been in service now for three winters, and so far as I know there has never been one single item of trouble in regard to leakage in that Kansas City line, and this particular joint has been very satisfactory.

These different arrangements all have to be viewed in the light of suitability and reliability. It is not easy to generalize. I want to thank Colonel Maury for his very instructive paper.

MR. N. S. HILL, JR.:⁴ I think the best thing Colonel Maury has done for us in this paper is to formulate the elements which ought to be considered in making a selection of the material to be used in long supply lines. It brings to mind how complicated the problem is, and I think Mr. Fuller's remarks should be supplemented and strengthened by adding that no figures of cost can reasonably govern in the matter of the selection of material for long supply lines, as each problem is an individual one. As Colonel Maury has pointed out, there are so many elements which must be considered—pressures, the character of the soil, the cost of materials in different localities, the quality of the water, and various other matters, each one which must be weighed on its own merits. The materials used and the type of line installed must be of a character to suit the particular conditions.

I think we are fortunate in having Colonel Maury's paper, for it leads us away from the old idea that there is only one material to use in pipe line construction. I believe water works men generally think solely in terms of cast iron. When cast iron cost from \$22 to \$28 a ton over a large section of the country, and its durability and dependability are taken into consideration, it was a pretty hard material to beat. Cast iron has now reached such prices, however, that it is a question of serious consideration whether

⁴ Consulting Engineer, New York, N. Y.

or not it is always profitable to use it for long supply lines, or whether we will not be forced to adopt steel or concrete, or other means in order to hold the cost of such construction within reasonable limits.

The question of carrying capacities as pointed out by Colonel Maury I think is very important in long pipe lines. Unquestionably if we can get such conduits of a material which will not deteriorate so as to reduce the carrying capacity we are going ahead in the construction of these pipe lines. I am not at all certain in my own mind that the day is not coming when the present practice of lining service connections with some non-corrodible material will be followed in large cast iron pipe lines in distribution work. When we see the effect of certain waters on the interior of cast iron pipe and distribution mains and when we take into consideration the effect that tuberculation has upon the efficiency of a distribution system so far as fire protection is concerned, I think we are going to be forced to adopt some means to prevent this tuberculation in order to keep the cost of replacement within reasonable limits.

I can add very little to Colonel Maury's paper. He always writes so thoroughly when he presents a paper to us that he does not leave much room for argument or discussion. I should like, however, particularly to emphasize the necessity of making a study of each individual problem for the purpose of selecting the proper material for long supply lines.

MR. E. G. RITCHIE:⁵ I should like to say a few words on the subject of wrought iron and steel pipes. I am from Melbourne, Australia, and have had considerable experience in the use of pipes of the different classes mentioned by Mr. Maury, but particularly in iron and steel pipes for supply of a city of 900,000 people, which is growing at present at the rate of close upon 40,000 additional population per annum. We have about 135 miles in length of wrought iron or steel pipes, mostly steel, varying in diameter from 18 to 57 inches of which 65 miles have been laid under my supervision, the whole entirely of Australian manufacture. We have lately contracted for a supply of 27 more miles of pipes, included in which is an 18-mile length of electrically welded pipes varying from 46 to 54 inches diameter.

⁵ Engineer of Water Supply, Metropolitan Board of Works, Melbourne, Australia.

Our first wrought iron pipe was laid in 1887 on a length of about 6 miles and was 30-inch diameter. It was riveted pipe with faucet and spigots with lead joints and about the year 1921, i.e., after 34 years life it was renewed. Now, our experience was this, the coating, originally of a mixture about 50 per cent Trinidad asphalt and 50 per cent coal tar, had more or less perished, and the internal incrustations had materially reduced the carrying capacity of the pipes. Moreover, on a length of about half a mile we had been having a fair amount of trouble due to leaks from perforations, as a result of external corrosions. We figured that so far as that half mile was concerned it could cost us no more to pay the interest on the cost of a new pipe than to continue to bear the cost of repairs. We decided therefore that, under all the circumstances, it would be wise to renew the whole 6 mile length of main. I fully contemplated that we would be able to put back most of the main, after repairs and re-coating. Our plan was as follows: for the upper or low pressure sections of the main, about one mile in length and with maximum head of 75 feet, we put down a new reinforced concrete pipe made by the Hume centrifugal process. I figured that with this mile of steel pipes not replaced we would have a sort of reserve from which renewals to the pipes to be repaired would be drawn, where the latter were found to be "beyond repair." We took the opportunity of winter time when the main was not in use to lift the 5 miles of pipe not yet dealt with, carted them to the nearest factory, cleaned them, patched them or put in new rivets where necessary, recoated them and relaid them with every expectation that they still had a long term of useful life to give. Now the net result of our operations was that after relaying the 5 miles of pipe, I had nearly all the first mile of pipes, lifted as a reserve, still on my hands, and as a matter of fact, our loss of the original pipes, i.e., the sum total of pipes abandoned as too costly to repair was only about $2\frac{1}{2}$ per cent of the total length of 6 miles originally laid. And from what I have observed in the use of mild steel pipes, I should expect results which, though perhaps not quite so favorable, would still compare very well indeed with the results achieved on those old wrought iron pipes, especially as our present day methods of coating are much superior to those employed on the old wrought iron pipes, I believe referred to.

I may say that we have used all classes of steel pipes. At first, we used riveted pipes, which we have long since ceased to employ,

on account of the fact that they are at best only a 70 per cent efficient pipe, as far as strength is concerned, and there are many objections to the presence of rivets in such a structure. (This remark does not apply to spirally riveted pipe but refers to the ordinary longitudinal and traverse straight riveted pipes as commonly used for larger sized pipes.)

In 1912 we used our first lock bar pipe and in our latest patterns we are using electrically welded pipes on which an automatic welding machine is to be employed. Both the lock bar and the welded pipes are 100 per cent efficiency structures.

The questions that arise in my mind, as a result of my own experience is, "When is a steel pipe worn out?" "In the large number of cases will it even pay you to let it wear out?" I have figured out that the time will surely come when the cost of repairs due to perforations will be such that it will be sound business to take the pipe up, patch it and recoat it and use it again, if not in the same place, at least in some other place. For, wherever it is in roads subject to traffic, it is doubtful whether you can leave it to its fate when its repair bill is becoming unduly high. There would be the danger, with water removed from the pipes, of eventual collapse in the roadway and, while under a concrete roadway, this collapse might not really take place due to the supporting action as a beam which the concrete possesses, still I cannot think it would be good engineering to leave that main there. Even if you could leave the steel pipes to the absolute limit of their life, and lift them and cart them away, it would always be the problem of cost of carting worthless pipes, and the difficulty of finding a disposal place for them. It, seems to me, therefore, a much more rational plan to lift them in good time, repair them where necessary and re-coat them, and again I would ask the questions. "What is really the limit of life of a steel pipe under such circumstances, i.e., taking into account the economic necessity for re-conditioning the main rather than allowing its complete destruction?" I think the answer would be that it is really very much greater than we ever supposed when we made our original calculations at the time it was first laid down.

MR. C. B. BURDICK:⁶ The Association is indebted to the author for a large amount of valuable data on pipe lines. It is particularly useful thus to assemble estimates of cost on a comparable basis.

⁶ Consulting Engineer, Chicago, Ill.

The financial comparisons of the several kinds of pipes are enlightening, even though there may be room for differences of opinion, as to values assigned. This general method of comparison, carried to its logical conclusion in each case, is the method by which this and other engineering problems must be attacked, unless a correct conclusion may be made from general experience.

The comparisons made by the author presuppose that, under the conditions outlined for his comparison, all four of the types considered are substantially equal except as regards the factors he mentions, namely cost, carrying capacity, life and leakage. Cast iron, steel and wood, have been used sufficiently long so that good results would be generally expected by engineers. While concrete has amply demonstrated its usefulness under gravity flow or moderate pressure, the knowledge of its use under higher pressures is rather limited. Within the next generation some things will be proved, upon which most engineers can only speculate today. We are fortunate to have the author's views on the use of this material, for he has had an unusual opportunity to study the problem recently.

It is suggested that it would add to the usefulness of the paper, to record the principal features of design for each kind of pipe, particularly the working stresses. The iron pipes and the steel pipes are very conservative in shell thickness, and data are scarce as to workable values for concrete pipes. Upon gravity supply lines, controlled from the upper end, with the relief towers mentioned; it would seem that a well-coated steel pipe might have a somewhat thinner shell, than has been used in the author's tables.

There are certain situations in which any of the pipes mentioned would be eliminated from consideration, or suffer serious disadvantage in comparison to the others. One city is in mind, served by a water capable of tuberculating well coated cast iron pipe with such rapidity as to reduce its carrying capacity 60 to 80 per cent in seven years. A cement lined pipe or a wooden pipe has important advantages at this place. In many plants, cast iron pipe progressively decreases in carrying capacity with age. This fact is so well recognized that a correction for age accompanies Weston's flow tables and the speaker has noted that, while individual lines of pipe could barely be expected to check the age-friction coefficient, the newer pipes and the average of the older ones do not miss it very far.

Steel pipes in the larger sizes, particularly under the higher heads, have an advantage in dependability particularly in main discharge

lines. Well protected steel pipe has been used successfully at Gary, Ind. for the past 16 years in the city distribution system, in sizes down to 6 inch diameter. The comparatively high friction loss in riveted steel pipe can be reduced by a cement lining, at a reduction in the total cost of the line per unit of carrying capacity, at the same time considerably increasing the life of the pipe.

In the far west *cast iron* suffers a heavy freight charge, and there are many enterprises in which its cost is prohibitive, as creating an investment impracticable of finance. In such places wood and steel have formed a most useful field, and concrete, if successful as a pressure pipe material, will be welcomed, as it promises a long useful life. In the eastern and middle states long supply lines are rare. The west however is going *far* for its water and the economies of main supply lines are vital to such water projects.

MR. WM. GORE:⁷ The paper by Mr. Maury is of exceptional value to waterworks engineers and there is much of interest to be discussed in it, but I would like to confine my remarks to the problem of the protection of cast iron and steel pipes from corrosion. During the discussion so far the inference has been given that the coatings of cast iron and steel pipes as now applied by dipping or painting are satisfactory. That has not been the experience of the speaker.

It is well known that not only does a defective coating shorten the life of a pipe but it also reduces its discharging capacity seriously during its active life. This is particularly so when the waters conveyed are soft or contain organic acids which dissolve out such impurities in the coating as calcium carbonate making the coating porous and permitting nodulation inside the pipes. Examination discloses the fact that this nodulation occurs even when the coating, if thin, appears to be intact, but undoubtedly porous. The case is bad enough with cast iron which has a surface permanently linked up to the main body of the metal but it is much worse with steel owing to the mill scale which has a tendency to crack away particularly due to the bending process of pipe manufacture and while at the time no amount of scrubbing with wire brushes will remove it yet later on it comes away, taking the coating with it and leaving the metal exposed in patches. In some industries it has now become common practice to allow the mill scale to rust off completely before a coating is applied with satisfactory results, but this would be difficult or

⁷ Consulting Engineer, Toronto, Ontario.

impossible with water pipes. The Coolgardie pipe line experienced considerable trouble due to defective coatings. The discharging capacity of this pipe along some sections after five years of use was reduced by 44 per cent. Examination of the inside of specimens of the pipe sent to England showed the coating almost entirely to have disappeared and upon the surfaces were a number of rust nodules up to about half-inch in diameter. The greatest surprise to the speaker and those he was associated with was that the discharging capacity of the pipe was reduced so much by the small amount of nodulation observed. The conditions of laying the Coolgardie pipe were especially trying and the discharging capacity fell off the most where the pipes had been exposed for about two years before being placed underground.

Recently in the case of a short length of 42 inch steel pipe painted with a standard asphalt composition the pipes were not well on the work before serious breaking away of the mill scale became apparent, necessitating repainting before laying.

The two cases cited may be exceptional but it is a world wide experience that a time diminution in the discharging capacities of both cast iron and steel pipes does take place which would seldom take place if a really satisfactory coating could be found, but concrete and wood stave pipes have the advantage that in most cases it becomes unnecessary to consider a time diminution of their discharging capacities. This is well brought out by the author in the working financial comparison in the case of a 54 inch pipe for all four classes. The most important item of cost is undoubtedly the first cost of the pipe laid in place. In the case of a 42 inch and 36 inch pipe at present under consideration, it is the intention to ask for bids for both steel and concrete pipe, cast iron for reasons of cost and wood stave for other reasons being out of the question. In this way we hope to be in a position to draw sound and satisfactory conclusions as to the best pipe for this case.

MR. WM. W. BRUSH:^a I agree with Mr. Gore, that the important question from the water works viewpoint, as to the distribution pipe, is the coating, both for cast iron and steel pipe. The dip tar coating as generally applied is acknowledged by all to be unsatisfactory, and yet the majority of us continue to accept it, knowing

^aDeputy Chief Engineer, Department Water Supply, Gas and Electricity, New York, N. Y.

that with even a mildly corrosive water such as New York uses, within twenty years the loss in the carrying capacity of the pipe will approximate 30 per cent. We should give up buying cast iron pipe of the larger diameters with the present dip coating, and, so far, Portland cement appears to offer the best protective coating for water mains. The manufacturers will give us both large and small pipe with any coating that is generally demanded, and the price will be dependent upon its cost. In recent years New York City has installed many miles of 66 and 72 inch steel pipe coated with what is known as "bitumastic," and also installed a two mile line of 36-inch cast iron submerged pipe, coated with "bitumastic." This coating has been used in New York for approximately eight years, and has been shown to be far superior to the dip coating.

The question of the coating and the resultant life of metal water pipes brings to the forefront the very vital question as to whether large cast iron pipe should or should not be installed under city streets. If a cast iron pipe breaks, usually a large section of the pipe gives way, and in the case of a 48 inch main the resultant flow may be at the rate of approximately 100 m.g.d. This flow quickly floods cellars and subways, destroying a large amount of pavement, and there is a resultant heavy monetary damage. A steel pipe may fail, but only by pulling apart, and the rent in the pipe is very small as compared with the area of the break in a cast iron pipe.

I understand that in Melbourne, Australia, only steel is used for pipe larger than 18-inches in diameter, due to the damage caused by breaks in the larger mains.

There is no more important question before the water works fraternity today than the question which has been brought up by Col. Maury in his paper, and we must give intensive thought to the solution of the problem, as to the material and coating that is best suited for both large and small size pipe, whether the material be of cast iron or steel. Col. Wood of the Board of Water Supply will be able to give you some details in reference to tests of coatings that were made on one of the New York steel pipes.

MR. LEONARD P. WOOD:⁹ The Board of Water Supply of the City of New York during the past ten years has laid many miles of large steel pipe from 66 inches to 11 feet 3 inches in diameter under two

⁹ Assistant Engineer, Board of Water Supply of the City of New York, N. Y.

entirely different sets of conditions. The larger pipes are parts of the Catskill aqueduct which brings water from the Catskill mountains to the City. These were laid as so-called siphons across such of the valleys as were not crossed by pressure tunnel. These pipes ranged from 9 feet 6 inches to 11 feet 3 inches in diameter and were all lined with two inches of Portland cement mortar and protected on the outside by a jacket of Portland cement concrete and an earth embankment. Ten of these pipes were entered last year after 6 to 9 years of service and, while not examined throughout, the mortar linings, whenever seen were found practically perfect. Of course, they were covered with slime as the interior of an aqueduct usually is, but the condition of the 2-inch lining was substantially as good as new, except that the surface was slightly softened and showed a slightly sandy texture in place of the almost polished surface left by the steel forms. This mortar lining promises to have an indefinite life. The only failure of the lining was at overhead stream crossings where the pipe, unprotected on the outside except for a 2-inch mortar envelope, had been exposed to severe winter cold. Here frost had spalled the mortar lining at the top of the pipe. In only one case has a mortar lining been dug through to the steel, this being a case where the mortar was obviously defective, and the steel, which had been pickled to remove mill scale, was found bright and entirely free from rust.

The other group of steel pipes consists of lines in the City streets; of these about $5\frac{1}{2}$ miles of 66-inch pipe were laid about 10 years ago. Most of this pipe was coated with one of the asphaltic dips in general use at that time. On one line, to which Mr. Brush has referred, about a dozen experimental coatings of different kinds were put in for comparison with the asphaltic dip. In 1922, through the courtesy of Mr. Brush, there was an opportunity to examine with him the interior of that part of this line containing 9 of the coatings including the asphaltic dip. Of these 9 coatings, bitumastic enamel was found to have given by far the best protection to the steel, the tubercles being much fewer and smaller than with any of the other coatings. This bitumastic enamel is a highly refined coal tar having such a high melting point that it has not yet been successfully applied as a dip but has to be brushed hot on the specially prepared pipe. The superiority of this bitumastic enamel over the other coatings examined was such that it was adopted for the coating of

14 miles of 66-inch and 72-inch steel pipe in the City streets, for which contracts were at that time in preparation, and most of which pipe has since been laid.

About 1916 the Board also laid about two miles of 36-inch flexible joint cast-iron submarine pipe under New York harbor. This submarine pipe and some of the approach piping was also coated with bitumastic enamel. When portions of this submarine pipe were examined about two years ago, the pipe was found in excellent condition both inside and out, the inside being in much better condition than adjacent cast-iron pipe coated with the usual coal-tar dip and than valves, etc. which had been painted with a cold asphaltic paint. In view of this showing, bitumastic enamel was adopted also for a new 42-inch flexible joint submarine cast-iron pipe now being laid in New York harbor.

With most soft waters and some soils, both the life of a steel pipe and its carrying capacity are determined by the life and efficiency of the protective coating. The mortar-lined pipes described seem likely to have a useful life equal to that of a masonry aqueduct. In the asphalt-dipped pipe, carrying the same water, pitting under the larger tubercles had penetrated one-fifth to one-sixth the thickness of the 16-inch plate at the end of 6 years; unless sooner recoated this pipe may be expected to show such leakage as to require extensive repairs under 30 years. The enameled pipe laid at the same time and in the same line promises to have not only a longer life, but, because of the fewer and smaller tubercles, to show at all ages a higher coefficient than the asphalt dipped pipe.

MR. J. E. GIBSON:¹⁰ I do not want to discuss Col. Maury's paper. I think he has pretty well covered the field, but during the war period Colonel Maury happened to be my boss, and he insisted upon our laying wood pipe. I objected strenuously; I like to kick anyway and I kicked on the wood pipe, but he rammed it down my throat. We laid about 30,000 feet of 20-inch continuous stave wood pipe, under a guarantee of 150 pounds pressure. After he got it laid and we tested it, we found the leakage to be somewhere in the neighborhood of about 200,000 gallons per day of 24 hours. The contractor got busy and ultimately reduced that to about 800 gallons per inch per mile, or about 80,000 gallons per day. We do not operate that however under 150 pounds pressure, but about 135 pounds, and since then our leakage has gradually grown

¹⁰ Manager and Engineer, Water Department, Charleston, S. C.

very much smaller than that, and I think today it is running less than 300 gallons per inch per mile.

Recently our county sanitary drainage commission who have charge of the highways, undertook to take an elbow out of the road, so that in taking this elbow out they would cross our wood main twice at a very sharp angle, about 350 feet of the pipe. I was afraid to leave the wood pipe under the improved pavement and undertook to relay cast iron pipe and in so doing had occasion to move the wood pipe some 2 or 3 feet horizontally and raise it some 6 feet at one point. I could not very well shut the main off, so I finally took the bull by the horns and moved this pipe with the water under 110 pounds pressure, the same as you would ordinarily move cast iron pipe. I must say that with very little additional trouble, except that we had to be a little more careful than with cast iron pipe, because it was a new undertaking, we moved the pipe, got it into the new location and then cut in our parallel cast iron main. Now there is one point about the carrying capacity of wood pipe, that is, unless the pressure or the staves are of sufficient thickness to retain their round shape, you will find a very decided falling off in the carrying capacity. In other words, if the pipe, due to the lack of pressure and the overhead burden of the ground, takes an elliptical form, you will get a lower discharging capacity.

Now about lining or coating, about two years ago, at Philadelphia I think it was, I said that very few of us knew anything about the carrying capacity of the pipe. I gave my experience at Charleston, S. C. Quite a few of the members at that time said "Oh well, you have a peculiar water down there; it does not exist;" but what I have heard here this evening sounds like mighty good cheer to my heart; it shows that we are not exceptional at Charleston. I find you are all getting this incrustation. I will tell you too that the quantity and thickness of the incrustation is due to the little tubercles, the size of the end of your finger, that set up eddy currents that restrict a six inch main to four inches, and a 24 inch main to 20 inches. There is only one answer to that, coating, cement lining inside and out. We first got one of the pipe foundries to line pipe for us; it cost us about \$5.00 a ton on the first work we did, about 15,000 feet of pipe from 24 inches down to as little as 4 inches. We worked it out together. We used natural cement about a quarter of an inch thick. Today you can get cast iron pipe lined with Portland Cement placed centrifugally, less than an eighth of an inch thick, and the inside surface looks like porcelain. I am told that the cost is little, if any,

over the ordinary tar coating that you buy from the foundries today.

MR. GUSTAV J. REQUARDT:¹¹ Colonel Maury has touched upon four cardinal points, beside several minor ones, to be considered when comparing material in large supply mains, and the information contained in his paper is extremely valuable. I might suggest three other points, which in some cases will have important bearing. These may be titled: fluctuating value of money, obsolescence, and future surface improvement.

After every war, costs of materials rise to a new level and larger bond issues are required for new construction; also, cheaper money can be used to pay off old bond issues. Such a condition favors the installation of the main constructed of material with the longest life since it will seldom need replacement; thus necessitating fewer bond issues and sinking funds may be set for longer periods.

In many cases, the main is designed to have a carrying capacity suitable to meet the demand which will prevail probably at the time the full life of the pipe is spent; in other words, an attempt is made to have the main serve its full usefulness for its whole life or that obsolescence be the same as depreciation. When this is considered in comparing materials for mains which have different durabilities, it is likely that smaller diameters will be selected for those materials with the shorter life. This would seem to favor the installation of wood over cast iron pipe, although several replacements with continually increasing diameters and on a rising cost curve may offset this apparent advantage.

Supply mains originally constructed in open country may be greatly built over as the time for replacement comes around, as cities sometimes expand amazingly in several decades. Paving and other surface structures are expensive, and their removal and replacement must be added to the cost of the main replacement when that becomes necessary. This consideration would favor that material which has the longest life and requires the fewest replacements.

The above three points should be considered where conditions are such that they apply in addition to the factors which are ordinarily considered and which were discussed so ably by Colonel Maury.

MR. T. H. WIGGIN:¹² There are a few matters in connection with the Catskill Aqueduct work which might be added to Mr. Wood's discussion. The speaker is no longer connected with that work but

¹¹ Consulting Engineer, Baltimore, Md.

¹² Consulting Engineer, New York, N. Y.

was designing engineer in charge of the development of the cement-lined, concrete-covered pipe for the inverted siphons. The siphons, except where there are pressure tunnels, are constructed generally of three lines of steel pipe. Mr. Wood has mentioned that these lines vary from about 7 feet 4 inches to 11 feet 3 inches in diameter of steel shell and in determining their design a rather interesting economic comparison was made which was very much along the lines of the author's paper under discussion. It was possible to make these siphons of four unlined pipes, having a coefficient in the Chezy formula, $v = c \sqrt{rs}$, of about 85, which was as high as we dared assume, or it was possible to use three smaller lines of cement-lined pipe, assumed to have a coefficient of about 120. It was found that the cost of these three lines, cement-lined and concrete-covered, was about the same as the cost of the four lines, but when account was taken of the greater life of the cement-lined and concrete-covered pipe, the comparison came out considerably in favor of the latter as compared with the four lines not so protected.

After the first seven or eight years experience with the Catskill works, two more lines were laid. It ought to be explained that, by reason of the siphons being made of a triple line of pipes, it was possible to defer two of the three lines for some years. When it was time to draw contracts for the second and third lines, various gagings of the first lines were available, some of which were made as much as five years after these first lines were put in service. The coefficient proved very satisfactory. Instead of approaching 120 (in the Chezy formula, $v = c \sqrt{rs}$) as was assumed very conservatively in the initial design, coefficients of only two siphons were below 140 and the general average was about 157 as shown in a little greater detail below.

DATE OF GAGING*	NUMBER OF SIPHONS GAGED	COEFFICIENT IN FORMULA $v = c \sqrt{rs}$.		
		Average	Maximum	Minimum
1915	7	164	165	163
1919	13	157†	173	130‡
1920	2	156	169	142

*Made by F. F. Moore, Designing Engr., B. W. S.

†The same 7 siphons that were gaged in 1915 gave in 1919 average 164, maximum 168, minimum 157.

‡Two siphons near Ashokan reservoir gave 130 and 131 respectively, probably because of the greater fouling by vegetable growths often noted near reservoirs. Excluding these two, average is 162 and minimum is 151.

Because of these favorable coefficients, also smaller losses than allowed found in siphon chambers and other refinements in the hydraulic computations, the second and third lines were made considerably smaller than the first lines. In the shorter siphons the reduction in one case was from 9 feet 2 inches finished diameter (9 feet 6 inches shell) to 7 feet (7 feet 4 inches shell). In one of the longest siphons, where influence of pipe coefficient was paramount and not obscured by the changes in siphon chamber losses, the reduction was from 9 feet 2 inches finished diameter (9 feet 6 inches shell) to 8 feet 2 inches finished diameter (8 feet 6 inches shell). As far as economy of deferring the second and third lines is concerned, this economy did not materialize, because in the meantime the price of material had increased so greatly that perhaps it would have been money in pocket to have placed all three pipes in the first place and of the larger size.

The so-called City pipe lines, or extensions of the Catskill Aqueduct in the streets of New York, were not cement-lined and concrete-covered. It was thought that pipes 66 inches in diameter were as large as could be put in the streets without too many alterations in sewer pipes below and in gas and other shallower pipes above. Considering that 48 inch (cast iron) was the largest pipe theretofore used in the streets of New York City, 66 inch was a considerable step. To cover them with concrete would have added 12 inches to vertical and about 24 inches to horizontal diameter. Without a concrete envelope or other stiffening device, such as steel flanges on the outside of the pipe, mortar lining was believed to be insecure.

With the idea that steel pipe protected by dip or paint would continue to be used, the experiments with coating described by Mr. Wood were inaugurated. The cast iron flexible-jointed submerged pipe across the Narrows in New York harbor had already been the occasion for seeking the best coating obtainable at any reasonable price. This same kind of coating, Bitumastic enamel, a refined coal tar product, was used experimentally on a considerable scale in the first 66-inch steel pipe laid in the City and after successful service for 7 years became the standard protection for these large steel pipes in the City.

In conclusion, the speaker would suggest that Col. Maury might well include not only mortar-lined steel pipes, but also mortar-lined cast iron pipes, which have been giving such satisfactory service at

Charleston, S. C., in his instructive series illustrating the kind of economic comparison that should precede choice of type of pipe.

A MEMBER: How long after those pipes were placed was that test made in which a coefficient of 150 was obtained?

MR. T. H. WIGGIN:¹² About 5 years.

A MEMBER: Tell us how smooth the pipe was finished compared to the pipe on exhibition in the manufacturers' exhibit.

MR. T. H. WIGGIN:¹² The lining was accurate in alignment and smooth as to surface. Most of the pipes were coated by pouring mortar around a wooden form and trowelling off any roughnesses existing after removal of forms. The proportion of the mortar was 1 to 2. One of the siphons was lined with a cement gum and trowelled smooth. Mr. Wood can describe in detail what the surface looked like after several years. It is a little more sandy than originally, showing a slight solution of the slick surface existing when the coating is first trowelled.

The mortar-lined and concrete-covered pipe was a very successful experiment. Of course, it was not an experiment in a sense, because mortar-lined and covered steel pipes were used so many years ago up through New England and in other parts of the country, so that we had a perfectly good line of experience, except that the Catskill Aqueduct pipe was very much larger, running, as said, up to 11 feet 3 inches in diameter. This large pipe required stiffening so that the lining would not collapse afterwards, because such a big pipe, when the pressure is removed, will flatten six inches or so and the lining inside would be likely to be cracked off. In the smaller pipe that difficulty does not exist.

MR. T. A. LEISEN:¹³ I might say on this question of coating, I am somewhat in the same position as Mr. Brush, as Chairman of the Committee to prepare standard specifications for steel pipe, I ran up against the same trouble, and the matter has been delayed, not because of the difficulty in preparing a specification insofar as it applies

¹² Secretary and General Manager, Metropolitan Utilities District, Omaha, Nebraska.

to the steel, but in connection with the coatings, and principally on that account the specifications will not be offered at this meeting of the Association. On the question of the deterioration of the coatings, so far as my experience goes I may say that in conversation last evening with the chief engineer of the Wilmington Water Department regarding a line of lock bar pipe laid by the speaker about 18 years ago, he informed me that they have been examining that pipe at least once each year and sometimes more frequently than that, and in the last examination made quite recently, the coating was found practically intact at the points where it was examined with no evidence of deterioration after a period of 18 years. About 2 weeks ago in making a 36 inch connection to a 48 inch line laid 12 years ago in Omaha, a section was cut out and carefully preserved, and the coating was still on, although it did show some evidence of blisters, and the coating was also covered with a slimy substance due probably to the lime in the water used at certain periods before the filtration plant was constructed, but the steel under the coating was in practically perfect condition. Those are the only two cases recently observed.

Mr. D. H. MAURY:^{2,14} This Association is to be congratulated on the fact that so many engineers of wide and varying experience should have taken the time to contribute discussions of this paper, discussions which were so instructive in their character and covered so wide a field, that they form a more valuable contribution to the Society's publication than does the paper itself.

One member in discussing the paper brought out the fact that the choice of the proper pipe to be used would not always be made solely on the basis of financial allowances for capacity, leakage and durability, and that there were sometimes certain conditions which might eliminate altogether the consideration of one or more of the classes of pipe discussed.

This is perfectly true; but the three points for which allowances were made are the three most important points to be considered; and in the example presented showing one method of computing these allowances, the assumption was made that the physical conditions would be such as to permit the use of any one of the four pipes concerned. The author believes that these allowances should always be computed before reaching any final decision.

¹⁴ Author's closure.

One factor, however, which is not a physical factor and for which no financial allowance can be made, may nevertheless in some cases strongly influence the selection of the pipe to be used.

This factor is the mental attitude of the client toward one or more of the classes of pipe under discussion. For example, there are men who staunchly maintain that, no matter what the physical conditions may be, they would never consent to the laying of wood stave pipe on any project under their control. Sometimes such men may be persuaded to forget their prejudices and to give this class of pipe its due, subject always to the limitations of its field of usefulness. This field is narrowed by the fact, stated in the paper, that there are certain conditions under which wood pipe should not be used at all.

There are other men, however, with whom it would be utterly useless to argue. You may put before them allowances such as are presented in the paper and explain these allowances step by step; the prejudiced client may agree with every step of the explanation and argument; and then, when the end has been reached and after the figures have shown that every conceivable allowance for physical conditions has been taken into account and reduced to a dollar-and-cent basis, and that the wood stave pipe is still the cheapest, the prejudiced one may still say, "Well, that's all right, but I would not use the wood pipe anyhow."

One of the most interesting points brought out during the discussion of the paper was the practicability, already demonstrated in several installations, of applying a thin and smooth lining of cement to the interior of cast iron and steel mains. The author believes that further development along this line may lead to great benefit in the future, for it is certain that most, if not all, of the coatings now commercially obtainable fail to prevent the formation of tubercles inside the pipe, or to give proper protection to its outer surface. On the other hand, as brought out in the paper itself, long experience with cement lined iron or steel pipe has demonstrated that its carrying capacity is not seriously diminished by age, and that the cement lining affords a practically perfect protection against the corrosion of the metal by the water in the pipe.

With these two facts established, the author believes that we may expect to see noteworthy developments in pipes having a steel shell, coated inside and out with cement or concrete. Whether in the design of this pipe the steel shell itself will be relied upon entirely to resist the internal pressure, or whether the steel shell will be thin and will

be depended upon, not for reinforcing strength, but solely as a water-tight diaphragm, the necessary reinforcement being provided in the form of steel bars or mesh, will be a question that can only be decided in the light of the local conditions and of the respective costs of the two classes of pipe.

The author is particularly fortunate in that his paper was discussed by so many of his personal friends, and for their complimentary remarks he wishes to express his grateful appreciation.

GOVERNMENT REQUIREMENTS AND PROFESSIONAL STANDARDS¹

BY GEORGE C. WHIPPLE²

In connection with recent service on several committees, the writer has had occasion to consider questions of "standards," "government requirements," "grades of quality," and the like, and has observed that much confusion exists in regard to the whole subject. There is a strong tendency nowadays to standardize and grade, to classify and "score," and there is also a desire on the part of many to have all this done by government. Some of the suggested laws and regulations looking to this end are of questionable legality; and it is probable that some sections of existing building codes and health laws would be declared unconstitutional if fully presented before the courts. It ought to be profitable, therefore, to consider the fundamental principles involved and a few of their applications.

POLICE POWER

When government makes a requirement in regard to the quality of food or water or sets up a building or plumbing code, it acts under what is called the "police power." This is an element of common law. One finds it in court decisions, not in statutes. It has never been exactly defined. The United States Supreme Court has even refused to define it. Usage has established the principle that its purpose is to *prevent injury*, not to produce benefits; to prevent the bad, not to secure the good. Its recognized scope is to prevent injury to the health, safety, morals—and some recent decisions have included welfare—of the people. Under the police power government may prevent the use of water likely to injure the health, may prevent types of building construction which threaten safety, may require certain protective devices in house drainage systems, and so on.

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Government may, of course, do things for the public benefit, may undertake *service* of one kind and another, may give advice, provide education, and in various ways endeavor to better conditions; but service is a very different thing from compulsion to prevent injury. Attempts at compulsory betterment by law have indeed been attempted, but, regardless of constitutionality, have not been successful.

GOVERNMENT REQUIREMENTS

There is often a disposition to regard a government requirement as a standard of excellence. Minimum requirements tend to become maximum practice. It is said that when, in Massachusetts, a minimum requirement was set for the amount of fat in ice-cream, some dealers who had been supplying products well above the requirements reduced the amount of fat to figures just within the law. The law prevented the bad; but did not tend to make the good any better. If a requirement is made too low, there is danger that this scaling down will occur; if it is made too high, it is likely to work injustice to many. Even if it is reasonably fixed between high and low, the effect is likely to be one of leveling. The trouble comes from the regard which the public has for law, a governmental minimum requirement being complacently viewed as adequate.

PROFESSIONAL STANDARDS

Professional standards ought to be higher than legal requirements. How absurd it would be to let law govern the fine arts! In Boston the police power is used to prevent hand-organs from playing if they are out of tune, and there are laws controlling billboards, but these do not set standards of excellence for either music or painting. Licensing doctors, lawyers, engineers, or plumbers may protect against incompetence, but does not encourage high ability. On the contrary, it exerts a leveling influence. In college, students are not given a degree unless they attain a "passing grade," which unfortunately represents mediocrity, not excellence. The D or E man is penalized by college law; no college regulation can force a man to get A's and B's. Stimulation to work for honors lies elsewhere. In many fields of business and even in structural work and sanitation where matters of health and life are involved, some persons are content if they just get by the law, and the public innocently

assumes that if the law is complied with that is enough. It ought to be reiterated by professional men, until the people understand it, that what the law sets up are not standards of excellence but limits to inferiority.

One reason why people get this false impression is because legal regulations sometimes go too far and too much into detail. This is true, for example, of plumbing regulations. Some of the codes are veritable specifications, obviously intended to improve practice and force people to install what is best. The underlying motive was good, and we should find no fault with such codes except this—that they ought to be set up as standards by the plumbing crafts and not made compulsory by law. Legal requirements concerning plumbing should go far enough to protect against injury to health, morals, and safety, keeping in mind that old plumbing causes more trouble than new plumbing and that protection needs to consider the future as well as the present, but this can be accomplished by relatively simple rules. If legal plumbing regulations were simpler and people got in the habit of depending upon the integrity and competence of plumbers themselves, instead of assuming that these men are merely complying with the law and skimping if they can, the present popular feeling against this craft would gradually clear.

In my opinion there is a wonderful opportunity for the professions, the crafts and the labor unions to establish and uphold standards of excellence. Let the public look to government for protection against the bad and the unsafe, but let it get in the habit of looking to these organizations for advice and coöperation in procuring what is best.

STANDARDIZATION

There is a strong demand also for standardization, especially standardization of the dimensions of things. There is need for the elimination from trade catalogues of many little-used articles, for "simplified practice" as Secretary Hoover calls it. This movement has already made head-way in several branches of the building trade. It is badly needed in the field of plumbing. When the Sub-Committee on Plumbing of the Building Code Committee of the United States Department of Commerce began its labors, it took up the subject of standardization, but, after devoting much

time to it, reached the conclusion, stated in its final report, that standardization is desirable but should be brought about by agreement and not by law. Unfortunately standardization in plumbing supplies and devices cannot be brought by agreement as long as it is hampered by having different legal regulations in different states and cities. The present chaotic condition of the plumbing laws stands in the way of a reform which would result in great economies. The adoption of a simple plumbing code substantially uniform in different states is needed not only for its own sake, but because it will make possible the standardization of dimensions and quality of plumbing supplies. Some of the plumbing regulations are matters of concern to water works engineers, and the movement to secure uniformity, under the leadership of the Department of Commerce, should receive the hearty support of the American Water Works Association.

Standard specifications issued by this and other associations, notably the American Society for Testing Materials, are professional standards, and their general use shows that it is not necessary to have them forced upon people by law.

GRADING

From time to time efforts have been made to grade or score water supplies according to their quality. Sometimes three classes have been proposed—good, bad, and indifferent. Sometimes five classes have been made—A, B, C, D, and E—the first three being regarded as passable, the last two not passable. Sometimes scoring on a basis of points or percentages has been tried. Comparisons such as these are useful and have their place; but their place is not the law. Viewed with reference to the police power, a water supply should be regarded as injurious to health or not injurious. There must be no debatable ground. If a certain criterion of purity is established, a water supply complies with it or does not comply with it. Even if classes or grades are established for statistical or other purposes, there must be somewhere a line drawn between the acceptable and the non-acceptable, because the object of the police power in this case is solely to prevent injury to health.

Grading water supplies according to quality on a scale from excellent to bad is useful. It is an incentive to improvement. It may be done by government—for example, the United States

Public Health Service or state departments of health—but in my opinion it is better to have standards of excellence set up as professional standards, or what in this case would be a better name, perhaps, “Water Works Standards.” Water works standards might appropriately be set up by the American Water Works Association working in conjunction with the American Public Health Association—the former representing the “producers,” the latter representing the interests of the consumers. This is in accordance with the principle above mentioned that standardization should be brought about by agreement of all the interested parties instead of by law. Obviously, there ought to be an interlocking of professional standards with government requirements, and for that reason the United States Public Health Service and perhaps the sanitary engineers of the various states might have a part in the proceedings. If “water works standards” thus arrived at were promulgated, they would set the pace for excellence and raise the general level of quality, so that the employment of the police power to prevent the use of water below the government requirement would seldom be necessary. The maintenance of a high standard of quality should be a matter of professional pride. If standards of excellence were set up by the joint action of water supply engineers and sanitarians, it is probable that there would not be so great a tendency as now to make government requirements too high.

UNITED STATES TREASURY “STANDARD”

In 1914 the United States Treasury Department, through the United States Public Health Service, promulgated certain interstate quarantine regulations relating to the quality of water used for drinking or culinary purposes provided on cars and vessels by interstate carriers. The regulations in particular provided that the number of bacteria and tests for *B. coli* should not exceed certain stated figures. Although not so intended, these bacteriological tests came to be applied to municipal and other supplies, and in many instances this unintended application has caused misunderstanding and complaint.

Accordingly, in 1922 the Surgeon-General of the United States Public Health Service took steps to revise these requirements. A large committee was appointed, the labors of which are now drawing to a close. The present, therefore, is an appropriate time to con-

sider the subject of professional standards. A slight delay in promulgating new government requirements will work no damage or hardship, and if they can be correlated with a graded series of standards, which extends both above and below the United States Treasury Requirements, it will be not only appropriate but beneficial.

In 1904 a committee of the Laboratory Section of the American Public Health Association issued a set of Standard Methods of Water Analysis. They were professional standards. Negotiations are now under way looking towards their revision and joint publication by the American Water Works Association and the American Public Health Association—a logical and much needed arrangement. If this idea can be further extended to the establishment of graded scales of purity of water, based on sanitary surveys as well as analyses, the advantages will be large.

Tentative suggestions for the revised Treasury Requirements have been distributed for criticism and already claims are being made that they are too high or too low. If they are really too high, the public water supplies of many cities, which have long been used without injury to health, will not conform to them. If too low, they will be regarded as stamping with approval supplies which are unsatisfactory. The discussion has already shown that there is a real demand for a standard of excellence, but that for the government requirement to be at the same time a limit of impurity and a standard of excellence is practically impossible.

In devising "professional" or "water works" standards of quality, many items need to be considered—color, turbidity, taste, odor, chemical analysis, bacterial content, and so on. It will be necessary to decide what is meant by such terms as pure and impure, good quality and poor quality, high, mediocre, and low quality, and the like. It may be necessary to have different scales for different parts of the country. It will certainly be necessary to consider the element of time or frequency. Perhaps some such scheme as the following might serve.

Supplies approved by government

Class A. High quality all the time.

Class B. High quality part of the time; mediocre quality part of the time.

Class C. Mediocre quality all of the time.

Supplies not approved by government

Class D. Low quality part of the time.

Class E. Low quality all of the time.

The writer makes no attempt to suggest a system of grading, classification, or scoring. It is a difficult and delicate matter, but it ought not to be impossible for water works engineers and sanitarians to decide upon some classification adequate for practical purposes. The present committee working on the revision of the Treasury Requirements may itself be competent to set up professional standards as well as minimum requirements, but it would certainly be better to have these standards backed by such large and vitally interested bodies as the American Water Works Association and the American Public Health Association, instead of being sponsored by the United States Public Health Service alone.

RÉSUMÉ

Returning once more to generalities, the writer advocates the following principles applicable alike to building construction, plumbing, control of water supplies, and other matters of sanitation:

1. Government requirements, not too high, intended to prevent injury, and justifiable under the police power, to be established by law.

2. Professional standards of excellence, standard specifications, grading, and the like, higher than government requirements, to be established by agreement, not by law.

3. Government requirements and professional standards to be interlocking.

4. Government requirements to be uniform in the different states as far as practicable, in order to facilitate the establishing of professional standards by agreement.

5. Professional standards to be varied geographically, or in other appropriate ways in order to meet practical conditions.

SODIUM IODIDE TREATMENT OF ROCHESTER'S WATER SUPPLY¹

BY BEEKMAN C. LITTLE²

Almost exactly one year ago³ there was given to this American Water Works Association the first public announcement of the treatment of a municipal water supply with sodium iodide as a preventive of goitre.

Within a few weeks after the Detroit Convention—at which this plan was explained—inquiries and comments about this treatment began to come into the Water and Health Bureaus at Rochester, where the test was being made, and they are still coming in.

They come from all parts of this country and several requests for information have been sent from municipal departments in foreign countries. Innumerable clippings from the daily press in many cities have been brought to my attention, and several of the popular magazines and health and medical journals have discussed, or at least directed attention to, the plan. Lest you get a mistaken impression, I should state that all these notices have not by any means been favorable to the scheme. They do indicate however a very wide and keen interest in the subject.

It is safe to say that the majority at present oppose, or to put it more correctly, are skeptical of the procedure and doubtful of any beneficial results. Some have been openly hostile and unreasonable in their opposition, while others I am glad to say are sincere in their disapproval, and their criticisms are earnest and helpful. Another class is open-minded on the subject and these are only awaiting further developments in Rochester before venturing any judgment on adopting the plan.

Before discussing some of these comments and criticisms it may be well to state again just what Rochester is trying to do, and how it is proceeding with this sodium iodide treatment of its water supply.

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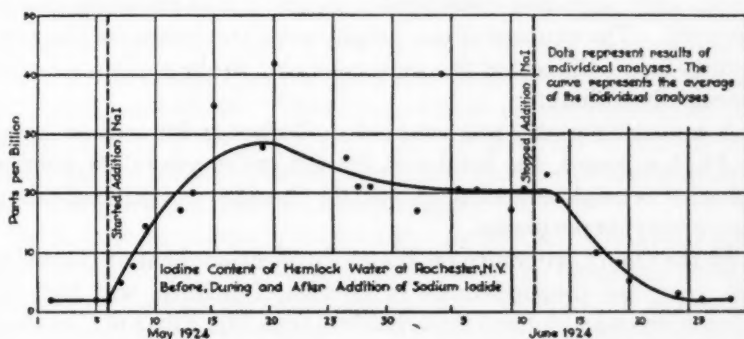
² Superintendent, Bureau of Water, Department of Public Works, Rochester, New York.

³ See JOURNAL, July, 1923, page 556.

It is the opinion now of most authorities that the disease called goitre is caused by a lack of iodine in the human system, and, in localities where goitre is prevalent, the giving of minute doses of iodine is a proper treatment.

It is the belief of the health officials at Rochester that, if every one living in such localities could receive each year this minute quantity of iodine, the disease would be stamped out. They are aided and abetted in this belief by the officials of the water bureau, and the public water supply is a means at hand by which this theory can be tried out.

In consequence, a definite amount of sodium iodide, proportional to the known consumption of water, is dissolved in Rush Reservoir, from which is taken Rochester's supply of water.



This treatment is given twice a year, once in the spring and again in the fall, and covers a period of about three weeks in each instance.

At present this seems to be the only practical way of being sure that every one—or substantially every one—in Rochester will get what is thought to be a sufficient quantity of iodine into his system.

We have been operating under this plan only a little over a year. The sodium iodide was first put into our supply in April 1923, then again in September of that year and we are now applying the spring dose for this year.

Sufficient time has not elapsed to admit of any definite results except that positively no ill effects of any kind have been noticed, other than those arising from heated arguments over the proposition. However, it may be significant that Doctor Goler, Health Officer of Rochester, states without making any claims that on a recent visit to one of the public schools he took pains to observe a large

class of the older pupils, and, counting the number of visible goitres, was impressed by the fact that there was an apparent decided decrease from one year ago. He was also quoted in the newspapers—I do not know how correctly—as saying that he did not care to make public announcement of just how much goitre there really is in Rochester. This will not give the impression, I hope, that Rochester is badly off, or worse in this respect than other cities. It merely means that we happen to be located in the goitre district in the region of the Great Lakes.

An indication of the prevalence in Rochester of this disease is a Health Bureau report that in one of our prominent educational institutions, on inspection, showed that over one-half of the 246 girls registered had visible thyroids, or in other words, goitre. It is worth while spending considerable money if this condition can be bettered. The expense of our prophylactic treatment for the community is just the cost of the sodium iodide: as the application costs practically nothing.

A contract recently was awarded in Rochester for sodium iodide at \$4.35 a pound, the total cost for the entire year (700 pounds) being in the neighborhood of \$3,000.00. In other words it costs about one cent a year per person.

At the Ohio Conference on Water Purification, held at Columbus last year, the preponderance of opinion, I believe, was that the scheme was wasteful and inadvisable—or as Mr. Ellms of Cleveland puts it—"it would be far more effective and much less expensive, to treat the individual for simple goitre, than to attempt the medication of an entire water supply."

To this we reply that it would be perhaps difficult and indeed expensive to find out and segregate just the individuals needing the treatment, and then to arrange for and insure each one taking his medicine. Our plan obviates these difficulties. We want to prevent *any* goitre from developing and so we treat everyone. Is not the practice of general vaccination a somewhat similar proposition, and no intelligent person disapproves of this wonderfully successful method of combatting small-pox.

A number of newspapers gave a good deal of publicity to an article issued several months ago, describing the great danger to the public of thus poisoning the water supply with iodine.

I feel that the daily press was misled somewhat and a little careless. The article was signed by a comparatively unknown doctor in a

large city, but in the newspapers he became a "prominent physician" and the pamphlet from which the article was taken was issued by the "American Medical Liberty League" which title naturally carries great weight—if you do not stop to investigate. I did investigate, and wrote to the Headquarters of the Society for enlightenment on its aims and purposes. I found that for \$2.00 I could receive a book telling of the "Calamitous prostitution of science by Pasteur and how his absurd microbe theory has been demolished." For \$5.00 this society would send me 100 pamphlets for distribution, containing a "crushing argument against vaccination." I could get, free, a number of blank pledges for myself and friends to sign agreeing to "Refuse and resist any compulsory medical inspection or medical treatment for myself or children, and to submit to no vaccination unless overpowered by force." Other literature sent me "because I was interested," tells how the chlorination of water has failed, and one leaflet proves by 50 tests that typhoid germs are not dangerous, and so on. There were thirty or forty pieces of this dangerous sort of reading matter sent me and yet—as stated—one widely quoted hostile criticism of our goitre preventive plan emanated from this American Medical Liberty League.

As to putting poison into our water supply, some of these same sort of critics will doubtless in a month or so complain because we did not start earlier to remove the fishy taste in the water, and for that we use copper sulphate. We are aiming at the prevention of so called *simple* goitre and some physicians have pointed out that our method might have a bad effect on some cases of exophthalmic goitre. This may be so, as I understand that some authorities hold the theory that iodine treatment in Graves Disease, or exophthalmic goitre, is deleterious. Yet Doctor McClendon of the University of Minnesota Medical School, who has studied goitre perhaps as much as any one in the country, writes me that Doctor Plummer—supervising all the exophthalmic goitre cases in the Mayo clinic at Rochester, Minnesota—has for many years been treating them with iodine, and one whole floor of the Kahler Hotel is full of these patients.

We feel that in our treatment of the water supply we will absorb no more iodine than the inhabitants in non-goitrous districts get from their food and water in its natural state.

Let me touch again upon the alleged wastefulness of our plan. An official, standing very high in the municipal government at Rochester, was quoted as saying, in effect, that most of our water

went towards sprinkling the streets and putting out fires and it was a crime to use iodine for this purpose. I think if he had fully realized what a very very small proportion of the water consumed in a city goes down the throats of the citizens, he would have made his statement still stronger. We have a consumption of 86 gallons per capita per day. The average person takes into his body—at a very liberal estimate—between two and three quarts, or less than one per cent of the total consumption. By this reasoning over 99 per cent of our sodium iodide is thrown away or wasted. If, however, we incline to this theory—and believe in it—how about our filtration plants and our chlorine installations? Why spend tremendous sums of money in making, each day, many millions of gallons of water pure and fit to drink, when we only drink one per cent of it?

It may not be absurd to look into this situation. In fact I know it is *not* absurd for I recall that a member of this Association, for whom I have a great admiration, (I think it was Allen Hazen) did delve—sometime ago—into this very question. That is, whether it would be possible or feasible to have a special system of water to be used only for personal purposes, such as drinking, bathing and the preparing of food. In a manner of speaking, we *do* waste a good deal of iodine by our plan, but the total cost is comparatively small and not to be considered at all if our goal is reached.

There is however an economic question involved. If our plan turns out to be a success and every municipality starts adopting it, what will become of the available supply of iodine and to what height will the price per pound of the commodity go?

This problem may prove to be a very perplexing one. It is possible that the process of obtaining iodine can be improved, or new sources discovered, so that the supply will meet the demand. I am not sufficiently informed to discuss this phase of the situation.

In my previous paper on this subject I mentioned the fact that salt—common table salt—had been proposed as a very good medium through which to introduce iodine to the human system. Every one uses salt in some form or other every day, and the proportion of table salt entering the human body—compared to the amount used—is very much greater than is the case with water, so the efficiency would be much higher and the drain on the supply of iodine much less.

We are not by any means certain that the treatment of water is the best way to meet the goitre situation, but at least it is *one* way, and we

think well worth a good trial. If, by exciting interest and investigation, it leads to other and better methods we will feel repaid.

There is just one suggestion I would make in closing; if you decide to start this treatment in your water supply, be sure and announce that you are putting *sodium iodide* in your water, rather than mentioning iodine. To many the word *iodine* means nothing but poison, and this fact I think has been the cause of most of the opposition that has arisen.

The details of the actual process of applying the sodium iodide has been omitted in this paper as that story has been told before, but, to any one interested, the Health Bureau or the Water Bureau of Rochester will be glad to furnish such information as may be requested.

DISCUSSION

DR. J. F. McCLENDON⁴ (by letter): It is with great admiration that I follow the work that is being done in the city of Rochester, New York, on the addition of sodium iodide to the city water supply. When the proposition was first put to me for criticism I had very little data for this purpose. Goiter tablets containing 10 mgm. of iodine each were being advocated to be taken at the rate of about three a day. Putting an equivalent amount of iodide in the water would be rather expensive. Other persons were advocating about one milligram a day and this, too, would be expensive.

After two years of research, I and my students have concluded that 0.01 mgm. a day is sufficient. This would be very well supplied by putting one part of sodium iodide in about one hundred million parts of water. One-tenth of a pound per million gallons would be ample. If this is not put in the water continuously, a proportionately increased quantity must be put in at intervals. The intervals should not be too long, but that part must be determined by experiment. The cost is very low.

In reply to the criticism that iodine is thus wasted in sprinkling lawns, etc. I can only answer that the iodine thus used in watering stock and irrigating food plants is returned again to the human system, and the actual waste in money is the smallest possible.

It has been shown in Switzerland that sodium iodide may be effectively given by adding it to all of the salt. Thus far, however,

⁴ Professor, Physiologic Chemistry, University of Minnesota.

only half of the salt used has been so treated. Since a person is at liberty to take his salt from any source it would be necessary to iodize all of the salt in the country. Nearly a thousand tons of salt are used every year in Minneapolis to sprinkle on the streetcar tracks to melt the ice in the winter. Salt is also used for curing hides, making soda and chlorine, and for a thousand other purposes besides human consumption. Furthermore, von Fellenberg in Switzerland has shown that a large proportion of the sodium iodide added to salt is lost in storage and it must be added at least 100 per cent in excess to make sure of its being there in the required amount.

It has been claimed that the use of iodine in tablet form is the most economical. Whereas sodium iodide costs about \$4.00 per pound, druggists may sell these tablets at the rate of \$2000 per pound for the iodine they contain, and a special wholesale rate may be made to schools whereby the school takes on the function of retailer, and the "small" price of \$1,000 per pound is charged for the iodine these tablets contain.

We can afford to waste a little iodide in sprinkling lawns and save considerable money.

As to using up the total iodine supply of the world; at present, iodine is controlled by a trust and an agreement has been made to throw away all of the Chilean supply five years out of every six in order to keep up the price.

During the war, iodine was produced in America from sea-weed off the Pacific Coast as a by-product of the potash plants. Owing to the flooding of the country with cheap German potash since the war, these potash plants have had to close down. If the demand for more iodine was made, the farmer would be benefited by more potash being produced.

The world supply of iodine is so huge (about fifty billion tons) we cannot conceive of it. At present it is nearly all in the sea but is extracted at a rapid rate by seaweed and an industry could be developed which would give helpful employment to quite a number of people in utilizing the various products from this seaweed.

DR. GEORGE W. GOLER:⁵ I read Mr. Little's paper with a good deal of interest. I agree with all he says. Could I attend the meeting I should probably say something like this:

⁵ Health Officer, City of Rochester, New York.

At the outset it ought to be distinctly understood that iodide of soda is not put in the water for the purpose of treating goitre. It is put there to prevent goitre. There is a distinct difference between prevention and treatment.

The only two feasible plans for the prevention of goitre are, first to iodize the water, the other is to iodize salt. We here in Rochester, as the speaker said, have iodized water. We should prefer, of course, to iodize salt. We do not believe that it is desirable to permit the child to grow to the age of 12 or 14, when goitre in this section presents itself, and then to treat that goitre with iodide. We do know that every mother should have iodide before the birth of the child. We do know that the child should have minute doses all through its life.

There can be no question concerning the value of iodide in the prevention of goitre. Iodide is just as necessary to the maintenance of the body in full health as are the vitamins. Now, if this be so, what matters how we get the iodide into the body as long as we get it in sufficiently minute quantities and get it in early?

It is said that the water method of getting iodide into the body is wasteful. We can not stop here to define this kind of wastefulness, but if it is wasteful to spend one cent per person per annum to prevent a dangerous disease then we are willing to plead guilty to the charges of wastefulness.

The question really before us is not, "how much" or "what way," but the everlasting "*how*" can we better get iodide to our people in goitrous regions so that we can prevent goitre?

MR. MAYO TOLMAN:⁶ From a biological standpoint there are two outstanding facts in the history of iodine; the discovery of the element in 1811 by Courtyos and the detection of its presence in the thyroid gland by Baumann in 1895. Baumann's discovery was merely an incident in his attempt to secure from thyroid tissues products that, when concentrated, might represent the substance that rendered desiccated glands therapeutically useful in certain cases of goitre. Subsequent investigations were directed chiefly to discovering the function of the iodine in the thyroid. The newer investigations tended to overshadow the earlier work in this field and, for the most

⁶ Sanitary Engineer, with N. S. Hill, Jr., consulting engineer, New York, N. Y.

part, the great work of Chatin, the French biochemist, seems to have been forgotten.

As early as 1850 Chatin maintained that goitre and cretinism could be averted by continued administration of small amounts of iodine. He gathered an immense amount of evidence in support of his iodine hypothesis. It was Chatin's observation that, in ascending the valleys of the Pyrenees and Alps, the content of iodine in the air and water decreased, but that goitre and cretinism increased which led him to assume an etiologic connection between endemic goitre and a paucity of iodine in nature.

Chatin's studies were investigated, in 1852, by a commission of the Paris Academy Des Sciences and many of his claims were found valid. Scientists, however, were not prepared at that time, before the demonstration by Baumann of iodine in the thyroid, to attach much importance to a mere trace of a chemical. Consequently it remained for the twentieth century to develop a plan of prophylaxis, supplying small amounts of the essential iodine where it is not easily secured in natural ways.

In my opinion Dr. Goler and Mr. Little, and with them the City of Rochester, deserve immense credit in adopting the plan of introducing iodine into the public water supply that the number of cases of goitre in their City may be reduced to a minimum.

Few people realize the extent of the disease and the disfigurement, discomfort and more that it occasions. An examination of more than half a million of school children in New York State in 1923 showed that more than 10 per cent of those examined had goitre. And it should be realized that these examinations covered the children in the non-goitrous regions as well as those in sections of the State where the disease is unduly prevalent.

In talking with me recently, an official of a State Department of Health maintained that the scheme adopted at Rochester was a waste of money, that it meant adding iodine to millions of gallons of water that were used for manufacturing purposes only and that far less than 1 per cent of the water to which iodine had been added was used for drinking purposes. Upon my making the comment that, as this country had no monopoly on salt or any other single article of diet to which the iodine might be added, as is done in Switzerland, I was told that each person should take care of himself. His contention was that with ample publicity the people would soon learn to take sufficient iodine to prevent their developing goitre.

If that is to be the attitude of our State Health Departments why should they spend small fortunes in trying to prevent syphilis when the majority of mankind knows that the number of cases innocently acquired are in a vast minority. Why do they watch the public water supplies with so much care when, judging by their attitude towards goitre, it should merely be necessary to tell the public to boil every drop they drink if they wish to avoid typhoid.

Rochester has initiated a step that must be followed by other communities in goitrous regions, and these communities will owe that City a debt of gratitude for its fortitude in carrying its tests to what must be a successful conclusion.

MR. SCOTLAND G. HIGHLAND:⁷ Simple goitre is a common disease among West Virginia children, and is prevalent to some extent among adults. Field surveys made by the state department of health in different sections of West Virginia have revealed the fact that goitre is one of the outstanding health problems of the state. A recent examination of school children in several counties, made by the State Department of Health, local boards of health, and school boards, discloses that from 43 to 64 per cent of the school girls have simple goitre. The average for all school girls examined is 57 per cent.

It is now known that goitre is due to a deficiency of iodine in the goitre districts of the country. As a result of a practical test of universal interest, it has been pretty well established by Beekman C. Little and Dr. George W. Goler, Rochester, N. Y., that simple goitre can be controlled and prevented by supplying the iodine deficiency through the public water supply by means of dissolved iodide salts.

Wherever there is a deficiency of iodine in the public watersupply, those in charge of the water utilities will wish to restore that iodine deficiency, which has been lost through long, natural processes. Therefore, a debt of gratitude is due Beekman C. Little, head of the Rochester Bureau of Water, for first giving the American Water Works Association the opportunity of broadcasting the discovery.

The people of West Virginia are watching with intense interest the research work being carried on by the Water Bureau and the Health Bureau, Rochester, N. Y., working together on a plan for treating and preventing goitre. Any new method for the prevention

⁷ General Manager, Clarksburg Water Board, Clarksburg, W. Va.

of disease should first have the approval of the local medical fraternity, and the chemists and bacteriologists, before definite action is taken by the water department.

Subsequent to the presentation of Mr. Little's paper at the Detroit Convention of the Association, May 23, 1923, on "Iodine Treatment of a Water Supply as a Preventative of Goitre," there was much favorable newspaper comment in West Virginia. The people are greatly interested and most of the physicians believe that the idea advanced by Mr. Little holds considerable promise.

But later a cloud appeared in the bright horizon when Joseph W. Ellms, Cleveland, presented a paper before the 1923 Ohio Conference of Water Purification at Columbus, on "Iodine Treatment of Water to Prevent Goitre." Among other interesting things, Mr. Ellms said:

The chlorine applied to practically all water supplied at the present time would have a tendency to decompose the sodium iodide introduced into a water and liberate iodine. While this element would not be lost, its combination with organic matter or its reaction with other mineral constituents might adversely affect its therapeutic value. It appears, therefore, to the writer that it would be far more effective and much less expensive to treat the individual directly for simple goitre, than to attempt the medication of an entire water supply.

Several months later the cloud was somewhat dissipated following a brief, but clear, discussion of Mr. Ellms' paper, by J. X. Cohen, Syracuse, N. Y., in which the latter sought to allay such doubts and fears as may have arisen because of Mr. Ellms' published address. In concluding his discussion, Mr. Cohen said:

The facts which I have recited should serve to eliminate any fears entertained concerning the possible nullifying effects of chlorination upon iodization of a water supply in a goitrous district.

Messrs. Little, Goler, Ellms and Cohen are men of high repute, and well informed persons appreciate any conclusion reached by any one of these specialists.

The purpose of this review is to emphasize the importance of obtaining more data, and to remind research workers of the keen public interest in the subject of iodine treatment of water to prevent goitre.

Mr. J. W. ELLMS:⁸ Mr. Little has presented a very interesting subject and one which attracted my attention when he wrote his first paper on the treatment of the public water supply of Rochester with iodine. The Health Department of the city of Cleveland asked my opinion in regard to it, and we made some figures in order to determine what the cost would be. The best price that we could get for sodium iodide from various chemical manufacturers was about \$4.25 a pound. The quantity which we would have to use, if we applied this sodium iodide to the public water supply of Cleveland for 30 days each year, would be about 3000 pounds and would cost, therefore, about \$12,750 per year. As I brought out in the paper to which Mr. Little referred, the amount of water in any water supply which reaches the stomachs of the community is relatively small, and therefore, it seemed to me that this method of applying or treating the community with iodine was decidedly wasteful. It also seems to me that, even if the sodium iodide is put into the water supply, it is quite unlikely that it will ever reach the consumer, because, depending upon the character of the water, I imagine that a great deal of this material may be absorbed, deposited in some way or used up by microorganisms. I think, therefore, we may be deceived as to the real amount of iodine we are getting into the systems of the drinking public. I want to be understood as not opposed to preventive medicine, because, of course, this is in a sense preventive medicine; but the question is just how far shall we carry it? Auto-intoxication caused by the stoppage of fecal matter in the lower intestinal tract is easily relieved by Epsom salts, but whoever heard of Epsom salts being put in the public water supply of a community. Is it necessary that such be done? If we start with such a form of treatment, the question is, where shall we stop?

Mr. J. J. HINMAN, JR.:⁹ I am not a representative of the League of Medical Freedom. I have been interested in Mr. Little's work on iodine for some time. I have been interested to a certain extent in the material that has been published in Switzerland and on the continent of Europe with regard to the goitre situation there. I have some doubts about the advisability of a general treatment of water supplies with iodine. My doubt in the matter is not

⁸ Engineer, Water Purification, Division of Water, Cleveland, Ohio.

⁹ Chief, Water Laboratory, State Board of Health, Iowa City, Ia.

based upon the same sort of information that Mr. Ellms' doubt is based upon. It is a little different sort of material. Extensive experiments over in Switzerland have been made on the use of iodine as a goitre preventive. Switzerland is the State which is most interested, I take it, in the study of goitre prevention. They have had that problem for many years, and hospitals are filled with cretins, persons who are incapacitated in various ways, traceable to this disease among their progenitors. Naturally Switzerland has appointed a commission to study the use of iodides. There were some people on that commission who were afraid of the use of iodides, but they seemed to have been definitely in the minority. The point which interests me most in this connection, however, is the study which was written up into a paper on the treatment of girls from the age of 15 to 21. It is generally admitted that goitre incidence is highest among girls. In many of the papers I have read, that point has been emphasized. Now the point I want to make in this connection is that among these girls from 15 to 21 the effect of the iodide treatment was markedly less than in children of lower ages, and it is claimed that the effect of the iodides on those still older is even less, although iodine administered to expectant mothers is said to have a beneficial effect on their offspring.

Switzerland has been much interested in the preparation of iodized table salt. Of course, there are iodized table salts on the market in this country at the present time, especially in Michigan. Manufacturers keep in touch with the literature and the new fads, and so we have this iodized table salt on the market here. It is made by adding a small amount of sodium iodide to the salt. I believe the Swiss Federal Government was either to control the sale in Switzerland, subsidize it or perhaps they were to have a monopoly; I have forgotten which. This study I mentioned about the girls of the older ages in the public schools emphasized strongly that too much faith must not be placed in the use of iodized table salt by the entire population of the country because of the lessened effect of the dosage as applied to older people. The same thing would appear to me to apply to the iodine treatment of the drinking water; in other words, it is the iodine which is taken by the children which may be expected to be the effective part of the iodine. Its effect upon the older part of the population, therefore, if this is true, will be materially less, so that not only will you have your 98 per cent loss that Mr. Little has told us

about, but your effective iodine absorption will largely be limited to the ages, say, below 15. Now whether or not this is important from a financial standpoint, I shall not presume to say. It is certainly worth a good many dollars of the money of the people of Rochester to avoid developing goitre among the children of the city.

Rochester I think has an adequate system of medical inspection of schools. Perhaps I am not well informed on the matter, but I think they have. In some communities, such as Grand Rapids, chocolate candies, which contain a small dosage of iodine, sometimes as an iodide, sometimes as an organic iodine compound, have been administered, I believe through the agency of the medical inspectors of schools. Just how the cost of administering these chocolate candies to the school children would compare with the cost of the iodine treatment as applied by Mr. Little, I cannot say, but at any rate those chocolate candies contain a very minute dose of iodine and the children could eat a good many without taking in any material quantity of iodine. The candies have no medicinal taste and are eagerly eaten by the youngsters as I know from experience with my own boys. I found the candies were very palatable. It seems to me that the administration of candies such as this is a more direct way of getting the iodine to the youngster than the addition of the iodine to the drinking water. The important part of the administration of the iodine is therefore that which is given to the children and to expectant mothers. It may therefore be better to attempt a more direct administration of the iodine through the agency of the medical inspectors of the schools.

MR. B. C. LITTLE:² I find that I have to leave, but I should just like to answer one or two things that were spoken of. Mr. Ellms says it is doubtful if we do get the iodine after we put the sodium iodide into our water. He did not say just that, but as regards that, we do, we make tests before the sodium iodide is put in, while it is being put in and for some time after, and find that the iodine content does increase in the water when it is taken out of the tap in Rochester, just as we expected it to do. I do not know how it would be with waters that are chlorinated very strongly or with waters that are filtered, but it does take place all right in Rochester. Then as to Mr. Hinman's statements about the treatment of girls 15 to 18 or younger—it is not the idea at all to treat people who have goitre. We think perhaps it does help them, but that is not the idea, it is to

prevent their getting goitre. The only way we can do that is to give them this before they get the goitre, not to treat them after they get it. As he says, girls who have goitre, who are older, from 15 on, perhaps the taking of iodine will not help them very much, but we want to prevent goitre developing. I think it has been proven in Switzerland that it does stop goitre to a very great extent. They have tried this prophylactic treatment with table salt and the goitre reduction has been something like from 87 per cent in a great many children down to 13 per cent, but we cannot treat all those we should like with chocolate or table salt because we are not sure they will get it. Some of the schools are private schools and there are children who do not go to school. The ignorant you cannot get at through the schools, but they must take iodine if it is put into the water supply. We are ready to try something else when it is proven better or when this system has failed, but we want another year or two. I did not want to read this paper because we have not any results that we can give out fairly yet, but I hope perhaps in another year or so it will be better.

MR. GEORGE C. WHIPPLE:¹⁰ This is a subject in which I am very much interested, but about which I know very little. Not knowing much, I have taken occasion to consult some of my medical friends whose names I do not feel at liberty to divulge, but they are almost all opposed to the idea of putting iodide into a public water supply. It certainly is not yet proved that simple goitre is merely a deficiency disease. That seems to be the prevailing idea at the present time, but when I was in Switzerland a few years ago, I took occasion to consult with some of the authorities there and found there was still a rather strong feeling that an infection is also involved. I was shown some interesting statistics at the University of Lausanne by young men who had been making a study of goitre in the various classes of the Swiss army. There seemed to be a rather strong correlation between the presence of goitre in certain cantons and the pollution of the water supplies in those same regions. That does not mean that the lack of iodine is not one contributing factor, but certainly we do not yet know all that there is to know about this disease. There is one thing that is certain, however, goitre is a very important disease.

¹⁰ Consulting Engineer, Harvard University, Cambridge, Mass.

It seems to me that the author of the paper, Mr. Little, has made a good point in saying we ought to call this the iodide treatment and not the iodine treatment. Bacteriologists of the war department have recently recommended the use of iodine in place of chlorine for disinfecting water in army camps, and it seems to have a good deal of merit; therefore, we ought to keep the two processes quite separate in our thoughts. My chief objection to the use of iodide in water is a general one; I think there is a growing restlessness on the part of water consumers on account of the addition of various chemicals to water. We have already seen that in connection with the use of liquid chlorine and sometimes even in connection with the use of alum. I do not like to see the practice of treatment with poisonous chemicals carried too far, lest there be a reaction which will sweep away a good many things which we know are desirable. The experiment at Rochester is one to be watched with interest, but in my opinion there are other ways of giving iodine to those who need it which are less wasteful and more effective.

DR. F. E. HALE:¹¹ I just want to speak on one point—the question of the policy of water treatment has been brought up in several of the discussions. When copper sulphate treatment first came in, there was a good deal of objection to it; people said we were adding poison to water. Let us not take that attitude. Let us treat each proposition on its own basis. When you add alum to water it reacts with the alkalinity and the alum is itself removed. When you add copper sulphate it is removed similarly, it settles in your reservoirs and stays there. The iodide treatment is a different problem. Recently in the last two or three years, the addition of sodium silicate to water has taken place to prevent corrosion, and other treatments are going to come. Let us not say that we do not want any more treatment of water, but consider each on its own basis as to its merits.

MR. A. E. GORMAN:¹² In the Rochester application of sodium iodide to water, they treated for two weeks in the spring and in the fall. I should like to ask why not put in relatively smaller dosages continuously throughout the year? You would certainly get away from the economic proposition of having a great demand for iodine at two

¹¹ Director of Laboratories, Mt. Prospect Laboratory, Brooklyn, N. Y.

¹² Sanitary Engineer, Water Department, Chicago, Ill.

seasons of the year. In case all cities should adopt that system, the seasonal demand might be very great. Is it not possible that, since the iodine is put into the water only twice a year, much of the iodine might be lost, due to its lack of absorption by the human system in that short interval; whereas if you put in a relatively smaller amount continuously the system might absorb what it needs and not lose possibly half of the iodine that was taken in during the two weeks' period? When applying a relatively large amount within a two weeks' period, a considerable proportion might be lost in the urine, whereas continual absorption would keep the thyroid saturated.

DR. MAX LEVINE:¹³ It seems that a great many physicians are opposed to the iodine treatment on the ground that they are not yet convinced that iodine deficiency is the cause of goitre, and that is a good fundamental objection from their standpoint. However, it is not always necessary to prove the cause in order to utilize an effective remedy. It is conceivable that iodine may be indirectly associated with the cause of goitre, although not the main cause. It is conceivable that goitre may be infectious and that iodine may have a considerable specific bactericidal action on those specific organisms. As my old teacher, Dr. Sedgwick, used to say, "the proof of the pudding is in the eating." If the administration of iodine eliminates goitre, it would be worth while employing it. Whether it is worth while adding it to the water supply is a matter to be considered on economic grounds.

I want to say another word in reference to the supposed poisonousness of iodine. There seems to be a general impression that iodine is a serious and violent poison. I had occasion a few years ago to look up the dose of iodine as given in the pharmacopoea. The dose given there was three drops as a maximum. Larger doses were thought poisonous. I have myself taken as much as 90 drops of ordinary tincture of iodine which I bought on the market, for a period of three months without any ill effects. It seems that iodine, even if administered in such large doses, is not retained by the body for any considerable time. Within 20 minutes after the administration of 30 drops of iodine, you can get a test for iodine in the sputum, within an hour you can get a test in the bladder discharges. A great many physicians are administering iodine in the form of tincture of iodine

¹³ Associate Professor, Bacteriology, Iowa State College, Ames, Ia.

in tremendous doses up to as high as 180 drops a day in milk, in the treatment of tuberculosis and pus infections of various kinds, so that the idea that iodine is a serious poison has been very much over emphasized.

MR. N. J. HOWARD:¹⁴ If the theoretical considerations regarding the application of sodium iodide are taken into account, it would seem that the prohibition laws might be unconsciously aiding in the treatment of goitre by increasing the consumption of water. My impression was that the medical profession largely opposed the treatment of goitre through water, on account of the impracticability of administering a therapeutic dose. The city of Cleveland quite recently, within the last five years, made a very extensive survey of the school children there, and they found, the same as in New York State, that there was a great deficiency in the children examined. They followed it up by enabling the children, with their parents' consent, to take a ten-day treatment, ten days in the spring and ten days in the fall, with truly remarkable results. I believe something like 78 or 80 per cent of the children treated with sodium iodide, in correct therapeutic doses, derived great benefit. The amount of water which would have to be consumed in any community, particularly in those cases where water is treated only in the spring and in the fall, would be so great, and it would seem to me, even if the cost were very small, that the money would be absolutely wasted. Time alone will indicate whether the policy of Rochester will be justified, but at present the amount of iodine contained in three or four glasses of water that a child might drink in a day, would be so small that the therapeutic value will be nil.

MR. W. W. BRUSH:¹⁵ Mr. Little told me just before he left that in Rochester the normal iodine content of the water is less than 1 part per billion and that, while the treatment is going on, they have 50 parts per billion. In the New York City supply, and Dr. Hale can correct me if I am wrong, I believe our tests show that we have about $1\frac{1}{2}$ parts per billion in other than the Long Island supply.

¹⁴ Bacteriologist in Charge, Filtration Plant Laboratory, Toronto, Ont.

¹⁵ Deputy Chief Engineer, Department Water Supply, Gas and Electricity, New York, N. Y.

DR. F. E. HALE:¹¹ It is 1.1 parts per billion in the Catskill supply and 1.3 parts in the Croton supply and 2.1 parts in the Long Island supply, per billion. As to Rochester, that 50 parts per billion is the peak of the chart. For three weeks the curve goes up, and then down again, and the peak is 50 parts per billion.

MR. WILLIAM GORE:¹⁶ I would like to ask Mr. Little what has become of the old correlation ideas between the Dolomite lime stone and goitre? It used to be considered in England that goitre was prevalent in the region of magnesium lime stone or dolomites. It is well known that in Switzerland the Swiss rocks are of the magnesium lime stone formation and that goitre is very prevalent there. I would like to ask Mr. Little what has thrown that idea into the discard.

MR. C. F. DRAKE:¹⁷ If Mr. Gore will take the Collins paper with a map of the United States showing the water supply and the total hardness of the water and follow it up with the map published by Dr. Crotti, of Columbus, in his new book on goitre and then follow for 10 years the United States census report showing the exophthalmic death rate, he will find that Oregon has the softest water in the country and the highest exophthalmic goitre rate in the country; in other words, we have been barking up the wrong tree. Let us get on the right track.

¹⁶ Consulting Engineer, Toronto, Ontario.

¹⁷ Division Superintendent, Pittsburgh Filtration Plant, Aspinwall, Pa.

WATER WORKS INFORMATION

BY FRANK C. JORDAN¹

The Indianapolis Water Company is under obligation to the members of the water works fraternity, who answered a questionnaire sent out by the Company on June 30, 1923. Certain of the information obtainable from the questionnaire has been tabulated and is transmitted for the attention of the members of this Association.

This information covers the water rates in 234 cities, assessments or frontage taxes for water main extensions, charges made for public fire protection service and other city uses by municipally operated water plants and trend towards the elimination of "free water." The data follow.

Water rates in 234 American cities

USES	AVERAGE RATES
Flat rate for water for 5-room modern house with bath, toilet, kitchen sink, wash-stand, laundry trays and sprinkling for 30' lot.....	\$20.52
Meter rate per 1000 gallons for first 7500 gallons used in one month by small consumers, such as residences, small stores, schools, etc.....	0.238
Rate for the first million gallons used in one month by larger consumers, such as office buildings, hotels, factories, hospitals, etc.....	121.47
Rate per million gallons for water used in excess of the first million gallons by large consumers, such as packing houses, factories, railroads, etc.	102.84

The supporting data follow.

¹Secretary, Indianapolis Water Company, Indianapolis, Ind.

NAME OF CITY	OWNERSHIP OF PLANT	IS WATER FILTERED	METERED WATER RATES		
			Consumption, 7,500 gal- lons or less during month. Rate per 1,000 gallons	Large consumers	
				Rate for first million gallons used during one month	Rate per million gallons for water used in excess of first million gallons in month
			<i>cents</i>		
Adrian, Mich.....	City	Yes	32	\$160.00	\$160.00
Akron, Ohio.....	City	Yes	21	180.00	160.00
Albuquerque, N. M.....	City	No			
Allentown, Penn.....	City	No			
Amsterdam, N. Y.....	City	No	10½	78.65	40.00
Anaconda, Mont.....	City	Yes			
Ann Arbor, Mich.....	City	No	16		80.00
Ashland, Wis.....	Private	Yes	24	150.83	133.33
Atchison, Kans.....	Private	Yes	35	130.45	100.00
Atlanta, Ga.....	City	Yes	13½	103.83	93.20
Bangor, Me.....	City	Yes	33½	95.00	66.64
Baltimore, Md.....	City	Yes	26½	133.34	133.34
Battle Creek, Mich.....	City	Yes			
Baton Rouge, La.....	Private	No	35	100.00	100.00
Bay City, Mich.....	City	Treated			
Bayonne, N. J.....	City	Treated			
Bedford, Mass.....	City	No	30		
Billings, Mont.....	City	Yes	33½	112.00	66.67
Binghampton, N. Y.....	City	Yes	10		60.00
Birmingham, Ala.....					
Bridgeport, Conn.....	Private		18	192.45	80.00
Bristol, Conn.....	City		24	136.31	86.67
Brockton, Mass.....	City	No	25½	137.83	133.32
Brunswick, Me.....	City	No	33½	104.00	80.00
Burlington, Iowa.....	City	Yes	30	105.25	100.00
Butte, Mont.....	Private	Treated	46	200.00	173.33
Cairo, Ill.....	Private	Yes			
Camden, N. J.....	City	No	25	100.00	100.00
Canton, Ohio.....	City	No	10½	86.00	80.00
Cedar Rapids, Iowa.....	City		24½	109.33	93.33
Champaign, Ill.....	Private	Treated	33		79.20
Charleston, S. C.....	City	Yes	24½	175.80	
Chelsea, Mass.....	City	No	14.7	147.00	147.00
Chester, Penn.....	Private	Yes	34½		115.00
Chicago, Ill.....	City	Treated	8½		83.33

NAME OF CITY	OWNERSHIP OF PLANT	IS WATER FILTERED	METERED WATER RATES		
			Consumption, 7500 gal- lons or less during month. Rate per 1000 gallons	Large consumers	
				Rate for first million gallons used during one month	Rate per million gallons for water used in excess of first million gallons in month.
			<i>cents</i>		
Clarksburg, W. Va.....	City	Yes	34½	\$168.30	\$150.00
Cincinnati, Ohio.....	City	Yes	16	160.00	160.00
Cleveland, Ohio.....	City	Yes	8	80.00	80.00
Colorado Spr., Col.....	City	No	15	81.55	80.00
Columbia, S. C.....	City	Yes	20	126.00	126.00
Columbus, Ohio.....	City	Yes	16	153.33	146.66
Concord, Mass.....	City	No	26½	119.00	100.00
Concord, N. H.....	City	No	22	104.53	50.00
Council Bluffs, Iowa.....	City	Yes	35	112.50	100.00
Covington, Ky.....	City	Yes	24	130.00	126.66
Dallas, Texas.....	City	Yes	30	203.50	200.00
Davenport, Iowa.....	Private	Yes	35	114.80	110.00
Dayton, Ohio.....	City	Treated	15½	71.75	60.00
Daytona, Fla.....	City	Treated	10	100.00	100.00
Decatur, Ill.....	City	Treated	50	107.33	70.00
Delaware, Ohio.....	Private	Yes	49½		146.66
Denver, Colo.....	City	Yes	17	100.00	80.00
Des Moines, Iowa.....	City	Treated	30		100.00
Detroit, Mich.....	City	Treated	8½		53.33
Dover, N. H.....	City	Treated			
Dubuque, Iowa.....	City	Treated	33½	120.43	80.00
Duquesna, Penn.....	City	No			
Duluth, Minn.....	City	Treated	20		100.66
Durham, N. C.....	City		30	190.00	180.00
Elmira, N. Y.....	City	Yes	40	99.16	80.00
El Paso, Tex.....	City	No			
Erie, Penn.....	City	Yes			
Everett, Mass.....	City	Yes	13½	121.34	80.54
Fall River, Mass.....	City	No	32	160.00	140.00
Fitchburg, Mass.....	City	No	24		60.67
Flint, Mich.....	City	Yes	20	110.17	106.66
Framingham, Mass.....	City	Yes	33½	120.00	120.00
Frankfort, Ky.....	Private	Yes	31		60.00
Fremont, Ohio.....	City	No	12	75.30	60.00
Fresno, Cal.....	Private	No			

NAME OF CITY	OWNERSHIP OF PLANT	IS WATER FILTERED	METERED WATER RATES		
			Consumption, 7500 gal- lons or less during month. Rate per 1000 gallons	Large consumers	
				Rate for first million gallons used during one month	Rate per million gallons for water used in excess of first million gallons in month
			<i>cents</i>		
Galveston, Tex.....	City	No			
Gardner, Mass.....	City		33½	\$200.00	\$200.00
Geneva, N. Y.....	City	Yes	33½	80.00	80.00
Gloversville, N. Y.....	City	Treated	16		46.66
Grand Rapids, Mich.....	City	Yes	9½	93.33	93.33
Grand Forks, N. D.....	City	Yes	40	56.55	150.00
Guthrie, Okla.....	City	Yes			
Hagerstown, Md.....	City	Treated	27	93.19	80.00
Hamilton, Ohio.....	City	No			
Hartford, Conn.....	City	Yes	16	134.00	80.00
Haverill, Mass.....	City	No	21½	100.00	100.00
Holyoke, Mass.....	City	No	5½	56.66	56.66
Houston, Tex.....	City	No	15	140.00	140.00
Hutchinson, Kans.....	Private	Treated	30	110.00	100.00
Independence, Mo.....	Private	Filtered	35	162.15	120.00
Ishpeming, Mich.....	City	Treated	12		50.00
Jackson, Mich.....	City	Treated	12	90.00	90.00
Jackson, Miss. /.....	City	Yes	26½	135.33	133.33
Jackson, Tenn.....	City	No	18	96.00	90.00
Jacksonville, Fla.....	City				
Jamestown, N. Y.....	City	No	26½	266.66	266.66
Jersey City, N. J.....	City	Treated	12	120.00	
Joseph, Mo.....	Private	Filtered	35	115.00	80.00
Kalamazoo, Mich.	City	No			
Kansas City, Kans.....	City	Treated	22½	122.13	80.00
Kansas City, Mo.....	City	Filtered	22½	122.13	91.47
Kenosha, Wis.....	City	Treated	16	102.33	60.00
Keokuk, Iowa.....	Private	Filtered	58	147.56	131.00
Kitchener, Ont.....	City	No	15½	133.33	80.00
La Crosse, Wis.....	City	No	20	100.00	81.00
Lancaster, Penn.....	City	Filtered	5	50.00	50.00
Lansing, Mich.....	City	Treated	16	76.24	64.00
Lawrence, Mass.....	City		20	200.00	200.00
Lawrence, Kans.....	City	Treated	38½		
Lebanon, Penn.....	City	Treated	27½	55.48	45.00

NAME OF CITY	OWNERSHIP OF PLANT	IS WATER FILTERED	METERED WATER RATES		
			Consumption, 7500 gallons or less during month. Rate per 1000 gallons	Large consumers	
				Rate for first million gallons used during one month	Rate per million gallons for water used in excess of first million gallons in month
			<i>cents</i>		
Lexington, Ky.....	Private		25	\$129.25	\$90.00
Lincoln, Neb.....	City	Treated			
Lockport, N. Y.....	City	Treated	10	31.30	30.00
London, Ont.....	City	Filtered	16	113.75	106.67
Lorain, Ohio.....	City	Filtered	26 $\frac{3}{4}$	133.80	120.00
Los Angeles, Cal.....	City		13 $\frac{1}{2}$	95.67	66.66
Louisville, Ky.....	City	Filtered	15	62.25	60.00
Lowell, Mass.....	City	Filtered	28	280.00	280.00
Ludington, Mich.....	City	Treated			
Lynchburg, Va.....	City	Filtered	24	106.40	80.00
Lynn, Mass.....	City	No	21	165.08	106.66
Macon, Ga.....	City	Filtered	25	110.00	60.00
Madison, Wis.....	City				
Manchester, Conn.....	Private	Treated			
Manchester, Vt.....	Private		30	100.00	100.00
Marion, Ohio.....	Private		25		
Marquette, Mich.....	City	Treated	13 $\frac{1}{2}$	43.03	40.00
Massillon, Ohio.....	Private	No	29 $\frac{1}{2}$	153.77	146.66
Meridan, Conn.....	City	Treated	15	100.00	100.00
Meridian, Miss.....	City	Filtered	30	105.50	60.00
Miami, Fla.....	Private	Treated	21 $\frac{1}{2}$	146.66	106.66
Middletown, Ohio.....	City	No			
Milwaukee, Wis.....	City	Treated	9 $\frac{1}{2}$	93.33	93.33
Minneapolis, Minn.....	City	Filtered	8	80.00	80.00
Missoula, Montana.....	Private	Treated	34 $\frac{3}{4}$	116.50	66.67
Mobile, Ala.....	City	Treated	15	100.00	100.00
Montgomery, Ala.....	City	No			
Mt. Clemens, Mich.....	City	No	20	148.27	146.66
Muscatine, Iowa.....	City	No	33 $\frac{1}{2}$	78.75	66.66
Nashville, Tenn.....	City	Treated	18 $\frac{1}{2}$	105.00	80.00
National City, Cal.....	Private	Treated			
New Bedford, Mass.....	City	No	15	100.00	100.00
New Britain, Conn.....	City	Treated	13 $\frac{1}{2}$	133.33	133.33
Newburyport, Mass.....	City	Filtered	25 $\frac{1}{2}$	140.00	140.00
New Haven, Conn.....	Private	Treated	18	100.00	100.00

NAME OF CITY	OWNERSHIP OF PLANT	IS WATER FILTERED	METERED WATER RATE		
			Consumption, 7500 gallons or less during month. Rate per 1000 gallons	Large consumers	
				Rate for first million gallons used during one month	Rate per million gallons for water used in excess of first million gallons in month
			<i>cents</i>		
New Orleans, La.....	City	Filtered			
New Rochelle, N. Y.....	Private	Treated	40	\$283.33	\$266.67
New York City, N. Y.....	City	Treated	13½	133.33	133.33
Niagara Falls, N. Y.....	City	Filtered	10½	40.00	40.00
Norfolk, Va.....	City	Filtered	22	106.00	80.00
Norwalk, Conn.....	City		25	55.50	50.00
Norwich, Conn.....	City	Treated			
Oakland, Cal.....	Private	Filtered	30½	273.33	253.33
Ogdensburg, N. Y.....	City	Filtered			
Oklahoma City, Okla.....	City	Treated	18	134.00	90.00
Olean, N. Y.....	City	Filtered	20½	86.66	86.66
Omaha, Neb.....	City	Filtered	16½	100.00	80.00
Ottumwa, Iowa.....	City	Treated	25	100.00	65.00
Owensboro, Ky.....	City	Treated	37½	83.60	80.00
Paterson, N. J.....	Private	Filtered	30	104.50	100.00
Pawtucket, R. I.....	City	Treated	30		
Peekskill, N. Y.....	City	Filtered	21½	160.00	160.00
Pekin, Ill.....					
Pensacola, Fla.....	City	No	30	138.50	125.00
Peoria, Ill.....	Private	No	36½	83.14	52.00
Phillipsburg, N. J.....	Private	No	35	118.33	66.66
Pine Bluff, Ark.....	Private	Treated	46	182.00	150.00
Pittsburg, Kans.....	City	No			
Pomona, Cal.....	Private		26½	110.67	106.66
Port Huron, Mich.....	City	Treated	10	41.25	20.00
Portland, Ore.....	City	No	10½	84.00	80.00
Providence, R. I.....	City		20	187.50	100.00
Quincy, Ill.....	City	Filtered	45	149.18	80.00
Racine, Wis.....			26½	111.57	66.40
Raleigh, N. C.....	City	Treated	30	157.50	120.00
Reading, Penn.....	City	Filtered	10½	106.67	106.67
Rensselaer, N. Y.....	Private	Treated	33½	128.00	120.00
Roanoke, Va.....	Private	Treated	30	127.80	70.00
Rochester, N. Y.....	City	No	18	158.00	140.00
Sacramento, Cal.....	City				

NAME OF CITY	OWNERSHIP OF PLANT	IS WATER FILTERED	METERED WATER RATES		
			Consumption, 7500 gal- lons or less during month. Rate per 1000 gallons	Large consumers	
				Rate for first million gallons used during one month	Rate per million gallons for water used in excess of first million gallons in month
			<i>cents</i>		
San Antonio, Tex.....	Private	No	20	\$77.04	\$72.00
San Francisco, Cal.....	Private	No	38 $\frac{1}{10}$	301.17	288.00
Savannah, Ga.....	City	No	12	81.80	60.00
Schenectady, N. Y.....	City	No			
Seattle, Wash.....	City	Treated	10 $\frac{1}{2}$	59.33	53.33
Sedalia, Mo.....	Private	Filtered	35	167.50	100.00
Seneca Falls, N. Y.....	Private	Filtered	26 $\frac{1}{2}$	136.33	133.33
Sharon, Penn.....	Private	Filtered	30 $\frac{1}{2}$	146.66	146.66
Sioux City, Iowa.....	City	No	25	107.10	100.00
Somerville, Mass.....	City	Treated			
Spokane, Wash.....	City	No	10	100.00	50.00
Springfield, Mass.....	City	Treated	29 $\frac{1}{2}$	69.50	66.66
St. Catharines, Ont.....	City	Treated			
St. Joseph, Mo.....	Private	Filtered			
St. Louis, Mo.....	City	Filtered	19 $\frac{1}{2}$	103.98	80.00
St. Paul, Minn.....	City	Treated	8	80.00	80.00
Streator, Ill.....	Private	Treated	32		
Superior, Wis.....	Private	Filtered	36 $\frac{1}{10}$	80.00	80.00
Tacoma, Wash.....	City	Treated	20	53.33	53.33
Tampa, Fla.....	City		22 $\frac{1}{2}$	136.50	120.00
Taunton, Mass.....	City	No	20	100.00	95.00
Tiffin, Ohio.....	Private	Filtered	53 $\frac{1}{2}$	243.13	213.33
Toledo, Ohio.....	City	Filtered	13 $\frac{1}{2}$	121.00	66.66
Topeka, Kans.....	City	Filtered			
Toronto, Can.....	City		13 $\frac{1}{2}$		
Tucson, Ariz.....	City		16 $\frac{1}{2}$	100.00	100.00
Victoria, B. C.....	City	No			
Waco, Tex.....			26	60.00	60.00
Walla Walla, Wash.....	City	Treated	24 $\frac{1}{2}$	80.00	80.00
Walkerville, Can.....	Private	Treated	8 $\frac{1}{2}$	65.73	63.33
Waltham, Mass.....	City	No	26 $\frac{1}{2}$	148.46	146.66
Warren, Ohio.....	City				
Waterbury, Conn.....	City	Treated	20 $\frac{1}{2}$	160.00	160.00
Waterford, N. Y.....	City	Filtered	30	120.00	120.00
Watertown, N. Y.....	City	Filtered	20	30.00	30.00

NAME OF CITY	OWNERSHIP OF PLANT	IS WATER FILTERED	METERED WATER RATES		
			Consumption, 7500 gal- lons or less during month. Rate per 1000 gallons	Large consumers	
				Rate for first million gallons used during one month	Rate per million gallons for water used in excess of first million gallons in month
			<i>cents</i>		
Wellesley, Mass.....	City	No	25	\$250.00	\$250.00
West Orange, N. J.....	Private	No			
Wilkinsburg, Penn.....	Private		28 $\frac{4}{10}$	164.26	120.00
Williamsport, Penn.....	Private	Treated	33	103.20	50.00
Wilmington, Del.....	City	Filtered	10	73.52	73.33
Wilmington, N. C.....	City	Filtered	24	128.00	128.00
Winnipeg, Can.....	City	Treated			
Winthrop, Mass.....	City	Treated	20	200.00	200.00
Worcester, Mass.....	City		20	100.00	100.00
Yakima, Wash.....	Private	Treated	25 $\frac{1}{2}$	80.56	74.00
Yonkers, N. Y.....	City	Treated	13 $\frac{1}{2}$	133.33	133.33
York, Penn.....	Private	Filtered	50	106.80	85.00
Youngstown, Ohio.....	City	Filtered	26 $\frac{3}{4}$	113.16	106.66

Many cities have adopted the policy of levying assessments or frontage taxes to cover a portion or all of the cost of water main extensions. This procedure is followed by municipally owned plants only, all water main extensions in privately owned plants being financed by the water company.

The following are typical cases of interest:

Cincinnati, Ohio: The property owner pays the cost of the mains in front of his property

Washington, D. C.: Abutting property is assessed \$2.00 per front foot.

Tacoma, Wash.: The property owner is assessed on basis of a 6-inch main.

Seattle, Wash.: Property assessed for cost of mains, payable in 10 installments.

Approximate cost \$2.00 to \$2.25 per linear foot of property.

Reading, Pa.: This property is assessed \$1.00 per front foot on each side of street

St. Paul, Minn.: Frontage tax of 10 cents per year for 10 years, on each side of street

Racine, Wis.: Property owner pays cost of water main up to 6-inch

Milwaukee, Wis.: Property is assessed on basis of cost of a 6-inch main

Minneapolis, Minn.: Property is assessed on basis of a 6-inch main

- Philadelphia, Penn.:* Property on both sides of street assessed \$2.00 per front foot
- Omaha, Neb.:* Property is assessed on basis of actual cost of installation, not to exceed the cost of a 6-inch main
- Detroit, Mich.:* Assessment of 50 cents per foot of frontage served
- Harrisburg, Penn.:* Assessment for 6-inch, 80 cents per front foot; 8-inch, 90 cents; 10-inch, \$1.00
- Hartford, Conn.:* Assessment for one-half cost of 6-inch main
- Kenosha, Wis.:* Assessment 80 cents per front foot, on each side of street, or \$1.60 per foot of pipe
- Kitchener, Ont.:* Actual cost of main
- Madison, Wis.:* One-half cost of main. Average assessment \$1.00 per foot
- Middletown, Ohio:* Assessment of one-half cost of main
- Lockport, N. Y.:* Assessment of property benefited
- Lincoln, Neb.:* Cost of main assessed against property benefited
- Grand Forks, N. D.:* Assessment against abutting property for entire cost of main
- Lake Forest, Ill.:* Special assessment
- Decatur, Ill.:* Special assessment against property benefited
- Elgin, Ill.:* Special assessment against property benefited
- Springfield, Ill.:* Entire cost of main assessed to abutting property
- Allentown, Penn.:* Assessment of \$1.20 per front foot on each side of street for 6-inch pipe; 8-inch, \$1.50; 12-inch, \$2.25
- Cleveland, Ohio:* Mains laid by private contract under supervision of water board or by taxation plan. Maximum charge \$2.00 per foot on taxable property
- Albany, N. Y.:* Special assessment
- Xenia, Ohio:* Special assessment
- Ann Arbor, Mich.:* \$1.00 per running foot
- Los Angeles, Cal.:* 80 cents per front foot of property to be served, provided required extension does not exceed 200 feet. Extensions in excess of 200 feet, \$1.60 per foot
- Louisville, Ky.:* Small distribution mains paid for jointly by the Louisville Water Co. and the prospective consumers
- New Britain, Conn.:* Annual assessment of 10 per cent of cost of main for 10 years
- Port Huron, Mich.:* 30 cents per linear foot of frontage on each side of street

Many of the municipally owned water plants receive revenue from the city budget for public fire protection service and water for city uses, but pay no city taxes.

The following are typical cases:

- Rochester, N. Y.:* \$126,000.00 per year for city water and fire protection
- Portland, Ore.:* \$75,000.00 for city water
- Omaha, Neb.:* \$180,000.00 for fire service
- Oklahoma, City, Okla.:* \$70.00 per hydrant per annum
- Des Moines, Iowa:* Annual revenue of \$350.00 per mile of pipe

Duluth, Minn.: \$50.00 per annum for each hydrant
Durham, N. C.: \$60.00 per annum for each hydrant
Ft. Scott, Kans.: \$30.00 per annum for each hydrant
Flint, Mich.: \$50.00 per year per hydrant
El Paso, Tex.: \$64.50 per year per hydrant
Kenosha, Wis.: \$39,000.00 per annum for fire service
Kansas City, Kans.: \$35.00 per year for each hydrant
Kalamazoo, Mich.: \$30.00 per year for each hydrant
Jamestown, N. Y.: \$40.00 per year for each hydrant
Grand Rapids, Mich.: \$35.00 per year for each hydrant
Amsterdam, N. Y.: \$70,000.00 per annum for fire service through 850 hydrants
Ann Arbor, Mich.: \$24,000.00 per year for fire service. 330 hydrants
Billings, Mont.: \$30.00 per year for each hydrant
Brunswick, Me.: \$30.00 per hydrant per annum
Charlestown, S. C.: \$45,000.00 per year. 662 hydrants
Dallas, Tex.: \$36.00 per year per hydrant
Denver, Colo.: \$22.50 per hydrant for fire service and city uses
Concord, Mass.: \$12,000.00 per year. 252 hydrants
Bay City, Mich.: \$75,000.00 per year. 1215 hydrants
Bangor, Me.: \$30.00 per hydrant per annum
Bristol, Conn.: 1-way hydrant—\$12.00 per year. 2-way hydrant—\$15.00 per year. 3-way hydrant—\$18.00 per year
Lansing, Mich.: \$35.00 per year per hydrant
London, Ont., Can.: \$17,000.00 per year. 1000 hydrants
Madison, Wis.: \$50,000.00 per year for fire service and city uses
Marion, Ohio: \$27.50 per hydrant per year
Marquette, Mich.: \$25.00 per hydrant per year
Missoula, Mont.: \$60.00 per hydrant per year
Racine, Wis.: \$25.00 per hydrant per year
Sedalia, Mo.: \$13,500.00 per annum. 253 hydrants
Toronto, Can.: \$964,818.00 for fire service through 7190 hydrants
Topeka, Kans.: \$62.50 per annum for each hydrant
Walkerville, Ont.: \$30.00 per annum on all hydrants installed by city
Framingham, Mass.: \$27.50 per annum for each hydrant
Norwalk, Conn.: \$15.00 per annum for each hydrant
Niagara Falls, N. Y.: \$25.00 per annum for each hydrant
Macon, Ga.: \$30.00 per annum for each hydrant
Ludington, Mich.: \$9,000.00 per annum for 230 hydrants
Lynchburg, Va.: \$18,000.00 per annum for 506 hydrants
Daytona, Fla.: \$7,000.00 per annum for 91 hydrants
Holland, Mich.: \$40.00 per annum for each hydrant
Jacksonville, Fla.: \$28,000.00 per annum for fire service through 991 hydrants
Kitchener, Ont.: \$35.00 per annum per hydrant
Lake Forest, Ill.: \$9,200.00 per annum for 186 hydrants
Winnipeg, Man., Can.: \$30.00 per annum for each hydrant
Victoria, B. C.: \$18.00 per annum per hydrant
St. Catharines, Ont.: \$20.00 per annum per hydrant
St. Paul, Minn.: \$14.00 per annum per hydrant

Waco, Tex.: \$12.50 per annum per hydrant
Gardner, Mass.: \$12,000.00 per annum for fire service and city uses
Spokane, Wash.: \$13,000.00 per annum for fire service
Pawtucket, R. I.: \$10.00 for each 1-way hydrant. \$20.00 for each 2-way hydrant, \$40.00 for each 4-way hydrant
Adrian, Mich.: \$100.00 per annum for each hydrant
Bedford, Mass.: \$20.00 per annum for each hydrant
Elmira, N. Y.: \$6,000.00 per annum
Hartford, Conn.: Fire department pays for installation and upkeep of hydrants
Milwaukee, Wis.: \$10.00 per annum for each hydrant
Newburyport, Mass.: \$5,000.00 for fire service
Seattle, Wash.: \$12.00 per annum for each hydrant
Tacoma, Wash.: \$78,000.00 per annum
Wellesley, Mass.: \$4,100.00 per annum
Wilmington, N. C.: \$40.00 per hydrant per annum
Winthrop, Mass.: \$3,000.00 per annum for hydrant maintenance

There is a growing tendency towards the elimination of so called "Free Water Service" as is evidenced by the following list of water companies or departments which furnish no "Free Service."

Oakland, Cal.....	Private Company
Cheyenne, Wyo.....	Private Company
Anaconda, Mont.....	Private Company
Ann Arbor, Mich.....	Municipal
Ashland, Wis.....	Municipal
Atchison, Kans.....	Private (flushing sewers only, very small)
Bangor, Me.....	Municipal
Bay City, Mich.....	Municipal
Bedford, Mass.....	Municipal
Beloit, Wis.....	Municipal
Billings, Mont.....	Municipal
Boulder, Colo.....	Municipal
Bridgeport, Conn.....	Private (water troughs only)
Bristol, Conn.....	Municipal
Brockton, Mass.....	Municipal
Brunswick, Me.....	Municipal
Chelsea, Mass.....	Municipal
Chester, Penn.....	Private
Dallas, Tex.....	Municipal
Davenport, Iowa.....	Private
Delaware, Ohio.....	Private
Denver, Colo.....	Municipal
Des Moines, Iowa.....	Municipal
Dover, N.H.	Municipal
Duluth, Minn.....	Municipal
Durham, N. C.....	Municipal
El Paso, Tex.....	Municipal

Everitt, Mass.....	Municipal
Flint, Mich.....	Municipal
Framingham, Mass.....	Municipal (for drinking fountains only)
Frankfort, Ky.....	Private
Fresno, Cal.....	Municipal
Gardner, Mass.....	Municipal
Grand Rapids, Mich.....	Municipal
Hamilton, Ohio.....	Municipal
Hartford, Conn.....	Municipal (park fountains only)
Holland, Mich.....	Municipal
Holyoke, Mass.....	Municipal
Hutchinson, Kans.....	Private
Jackson, Mich.....	Municipal
Jacksonville, Fla.....	Municipal
Jamestown, N. Y.....	Municipal
Kansas City, Kans.....	Municipal
Kenosha, Wis.....	Municipal
Keokuk, Iowa.....	Private
Kitchener, Ont.....	Municipal
Lake Charles, La.....	Private
Lansing, Mich.....	Municipal
Lawrence, Mass.....	Municipal
London, Ont.....	Municipal
Lowell, Mass.....	Municipal
Ludington, Mich.....	Municipal
Lynchburg, Va.....	Municipal
Madison, Wis.....	Municipal
Manchester, Vt.....	Private
Meriden, Conn.....	Municipal (fire houses only)
Milwaukee, Wis.....	Municipal
National City, Cal.....	Private
New Rochelle, N. Y.....	Municipal
Niagara Falls, N. Y.....	Municipal
Norfolk, Va.....	Municipal
Paterson, N. J.,.....	Private
Pawtucket, R. I.....	Municipal
Pomona, Cal.....	Private
Racine, Wis.....	Municipal
Rensselaer, N. Y.....	Private
Roanoke, Va.....	(3 drinking fountains only)
Rochester, N. Y.....	Municipal
San Francisco, Cal.....	Private
Seattle, Wash.....	Municipal
Sedalia, Mo.....	Municipal
Seneca Falls, N. Y.....	Municipal
Sharon, Penn.....	Private
Spokane, Wash.....	Municipal
St. Catharines, Ont.....	Municipal

St. Paul, Minn.....	Municipal
Streator, Ill.....	Private
Tampa, Fla.....	Municipal
Tiffin, Ohio.....	Private
Toronto, Can.....	Municipal
Victoria, B. C.....	Municipal
Waco, Texas.....	Municipal
Walla Walla, Wash.....	Municipal
Waltham, Mass.....	Municipal (drinking fountains only)
Wellesley, Mass.....	Municipal
West Orange, N. J.....	Private
Wilkinsburg, Penn.....	Private
Williamsport, Penn.....	Private
Winnipeg, Can.....	Municipal
Winthrop, Mass.....	Municipal
Brazil, Ind.....	Municipal
Lafayette, Ind.....	Municipal
New Castle, Ind.....	Municipal
Richmond, Ind.....	Private
South Bend, Ind.....	Municipal
Terre Haute, Ind.....	Private
Vincennes, Ind.....	Private
Washington, Ind.....	Private (drinking fountains only)

DEVELOPMENT OF WATER PURIFICATION¹

BY GEORGE W. FULLER²

Water purification by means of sand filtration was first established in London ninety-five years ago. In those days it was the purpose to get clean water acceptable to sight and smell. That viewpoint prevailed for some fifty years and filtration was adopted at many important European cities.

The first guide-post along the road to progress in America came from the thorough-going investigations of European filtration practice by the late J. P. Kirkwood, for many years chief engineer of the Brooklyn Water Works, who was especially commissioned to make this investigation for the city of St. Louis. His published report was a classic on this subject and was translated into several foreign languages. The excessive muddiness of the Mississippi River at St. Louis, compared with the waters of Western Europe, was such that St. Louis did not adopt filters. The only immediate outcome on this side of the Atlantic of those splendid investigations was the building of two filter plants some fifty years ago by Mr. Kirkwood at Poughkeepsie and Hudson, N. Y. Each derived its supply from the Hudson River and the city of Poughkeepsie still continues this method with more or less modifications during recent years.

In the middle 'eighties, two important events occurred in relation to the quality of public water supplies. The principal one was the recognition by the leading sanitarians of the germ theory of disease. The second was the establishment of laboratory methods based on the new science of bacteriology. Water examinations quickly took on a new aspect as compared with earlier records comprising chemical tests only. In a short time numerous investigations were under way to record the bacterial removal by various purification processes, operating under different conditions as to rates of filtra-

¹Abstract of paper read at Convention of Canadian Section. Complete paper in *Canadian Engineer*, March 11, 1924.

²Consulting Engineer, New York, N. Y.

tion, thickness of sand bed, size of sand and other items dealing with the economics of the situation.

Those were the days when terrific epidemics of typhoid fever and other water-borne diseases were of frequent occurrence on this side of the Atlantic. Death rates from 25 to 100 times as great as now found in dozens of cities were by no means unusual.

In 1892 a severe outbreak of Asiatic cholera occurred in Hamburg and through shipping channels was spread to various ports including vessels held in quarantine in New York Harbor. This danger stimulated activities at numerous places in respect to water filtration. Particularly so because of the fact that while Hamburg, deriving its water supply from the River Elbe, suffered so severely from cholera, its neighboring city of Altoona, enjoyed a substantial immunity, although its supply prior to its purification by filtration came from the same polluted river.

The Massachusetts State Board of Health at that date had been investigating for several years the engineering, chemical and biological aspects of various means of purifying water and sewage. Knowledge of the efficiency of filters in removing disease germs, coupled with a potential danger from cholera then in New York Harbor, led to prompt action on the part of the late H. F. Mills, engineer member of the State Board. The result was that the typhoid-fever-scourged city of Lawrence, Mass., installed a sand filter with commendable promptness. A few years later the city of Albany installed filters for the purification of its polluted supply from the Hudson River, taken from an intake only a short distance below Troy.

Investigations at Louisville, Cincinnati and Pittsburgh with rapid filters, embodying the use of coagulants and sedimentation in relatively large basins, brought forth a program which allowed satisfactory solution of water purification problems for those cities deriving their supply from muddy rivers. Beginning with the Little Falls plant of the East Jersey Water Company, which has supplied a dozen or more cities in northern New Jersey since 1902, the so-called mechanical or rapid sand filter has been adopted at hundreds of cities and towns in America with hygienic results which have been very satisfactory.

About fifteen years ago it was found that a large proportion of the objectionable bacteria in water might be eliminated by chlorine. This process has been adopted very generally in America as one

means of purifying water. In some instances its use is the sole method of treatment while in other cases its use is in conjunction with filtration, either to serve as a factor of safety, hygienically, or with the purpose of permitting economies as compared with filtration practice of earlier years. Chlorination is a very helpful procedure, but too much has been expected of it in many places. Its efficiency depends upon having the right quantity of chlorine present in all of the water to be treated and upon this result prevailing during each of the 1440 minutes per day. The difficulties are that in some instances there are periods when insufficient chlorine actually reaches the water to destroy objectionable bacteria, while there are other instances where there is an over dose with corresponding complaints as to tastes and odors. The presence of trade wastes in some supplies has also limited the usefulness of chlorination.

When chlorination is practiced in conjunction with filtration the required quantities of chlorine are less than for unfiltered water. This and advance in the art of its application cause it to become rightfully a useful factor of safety in conjunction with filtration plants.

These comments touch upon a few of the more important developments of the past century in the field of water purification. They deal with a subject that is both old and new. It is old in that it deals with a branch of municipal sanitation which by experience has demonstrated its importance for nearly one hundred years. The subject is new in the sense that the art of water purification is moving forward steadily and in a technical sense is perhaps engaging more attention now than it did a dozen years ago, in respect to getting reliable results under a great range of varying conditions from local supplies and with due regard to the economics of the problem.

A few years ago the typhoid toll in America was a substantial burden upon our population in that annually there were over 20,000 lives lost from typhoid fever with 10 to 20 times as many more suffering from the disease. Economically this meant great waste. This has been variously estimated at from \$5,000 to \$10,000 per single death, indicating that the total annual loss would reach figures of \$150,000,000 or more.

Statistics by the Department of Commerce covering the entire registration area show a reduction in the typhoid death rate from 35.9 in 1900 to 7.5 per 100,000 in 1922.

In speaking on this subject here in Hamilton, I am reminded that in this city it is well to call attention to several different items, as follows:

This city, which derives its water supply from Lake Ontario and furnishes it to citizens without any purification, by either chlorination or filtration, is one of the few large cities on or near the Great Lakes which has not adopted any means for water purification or taken steps toward that end.

While Hamilton has enjoyed the benefits of protection from its own sewage flow in a degree not found at some cities elsewhere, yet its use of an unfiltered Lake supply is a custom which is at variance with the best practice as found elsewhere.

Perhaps some mention should be made of the fact that in the Great Lakes basin attention has recently been given to the fact that at Rochester, N. Y., the custom was adopted quite recently of adding an iodine salt directly to the water supply to correct deficiency of this element. Its purpose is to lessen the prevalence of common goitre and it is said that the results are gratifying, although convincing data are not yet available.

In conclusion let me state that I recognize that the last thirty years have seen great progress in many branches of municipal sanitation. Several of them are related to the reduction of typhoid fever death rates, such as improved milk supplies and vaccination against typhoid. But none of them are of more importance than the elimination of polluted water supplies as delivered to the citizens. Purification methods have been of enormous aid in bringing about those improvements. Not only is there available the filter plant, but also chlorination. Furthermore double filtration is available as practiced at Albany and Poughkeepsie and several places abroad. No longer can it be said that means are not at hand for treating water supplies adequately and economically, as gross revenues of water departments providing filtered water seldom exceed one and a half or two cents per person daily.

SEDIMENTATION IN THE PURIFICATION OF WATER AT CEDAR RAPIDS, IOWA¹

BY C. O. BATES²

A matter of first importance in the process of water purification in the Cedar Rapids Plant has been the introduction of a settling basin. The basin was rather hastily improvised to relieve an approaching condition which was proving serious. The demand for water had been constantly increasing while there had been a constant deterioration of the plant due to all over-worked parts. While at the same time there had been for a third of a century an increase in the pollution of the river where we get nearly all of our water. This increase of pollution is evidenced by the increase of chlorin as chlorides. Thirty years ago the chlorin was a very little more than three parts per million, today it is nearly ten parts per million. This may be accounted for by the increase in population in the Cedar River's drainage basin, but more particularly by the greater number of homes that have made sanitary sewer connections. Industrial wastes have also added a certain amount of pollution.

Forty-seven years ago when the water plant was built the water was taken from the Cedar River and pumped directly into the city mains without treatment. The city was supplied with water for about seven years by this method. Three artesian wells were then drilled and put into use which supplied the city with water satisfactory for all except industrial purposes. This condition lasted five years. The wells then began to fail. This, together with increased demand for water, on account of increased growth of the city, was the cause of the greater part of our water being brought from the river.

The question of a settling basin has been a matter for consideration from time to time for the past thirty-five years, but there is absolutely no surface space for such a basin in the vicinity of the water plant. The difficulty for the present has been fairly well met by building a wooden structure of one quarter of a million gallons

¹Presented before the Iowa Section Meeting, November 2, 1922.

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capacity, 12 feet above the ground level, covering it completely and screening it at all points where the air has access. The basin was designed and constructed by Superintendent H. F. Blomquist.

It is divided into two sections each of which is about 85 feet long and 25 feet wide, and are connected by a flume which permits the water to pass from one section to the other. Each section is divided into two channels. The water enters the west section on the north side from the river, passes down the channel, which is $12\frac{1}{2}$ feet wide and 8 feet deep, the entire length of the section, curves around into the channel on the south side, returns the length of the section and passes through the flume to the east section, where it traverses the entire length of the section twice, completing in its entire circuit a distance of 340 feet and passes over 5 transverse baffles. The time the water is in the basin is about one and five-tenths hours.

The water, coming from the river, receives the alum just before it enters the pump which forces it up into the basin. The journey through the pipes from the pumps to the basin is about 200 feet. On entering the basin the water is given a whirling motion by turbine-like vanes as it is released. This whirling motion completes the thorough mixing of the alum with the water. The floc just begins to form as it enters the basin and a visible increase is noticed throughout the entire journey in the basin, being very conspicuous where it leaves for the filters. It is, however, broken up into fine particles in passing through the pipes to the filters.

WHAT THE BASIN HAS ACCOMPLISHED

The basin was installed in active service February 3, 1922. During the first sixty-eight days of service there was accumulated in the bottom of the tank 400 tons of sediment, approximately three hundred million gallons of water having passed through the basin. This makes an average of 6 tons per twenty-four hours of sediment retained by the basin.

The basin was thoroughly washed on May 6 and 7 and was run for one hundred and thirty-seven days before a second cleaning on September 20. During this period a skimmer was installed in each basin, which carries off all the sediment that rises to the surface of the water, and transfers it to sewer pipes. The amount accumulated during the summer averaged somewhat less than during the spring months. The average was $4\frac{1}{2}$ tons per twenty-four hours, amounting to 650 tons during the one hundred and

thirty-seven days. The average during the spring and summer was a little over five tons per day. This has been a great relief to the filters. In fact, it would have been impossible to have given the city satisfactory water during the spring and summer months of this year without this basin.

The sediment was an average taken from number of places in the basin. After making a determination of the average sample as to total weight of sediment in both spring and summer determinations, an average sample of the sediment was reduced to a dry powder, and found to be four-fifths water and one-fifth solid matter.

Our conditions would be improved especially as to taste and odor, if we had another basin of size equal to the present one. This would help us to take care of the water during the flood season. It would also enable us to permit the water to pass more slowly through the basin and to remove a larger amount of sediment. It has been our aim at all times to make safety the first principle and we think we have fairly well accomplished that. The number of bacteria in the final effluent is reduced to a minimum of two or three per cubic centimeter. We feel sure that the quality of the water would be improved by enlarging the means of purification by the basin. We feel assured of this because of the great work that the sedimentation basin has done so far. The question of the quality as to taste and odor is a complicated one involving the knowledge of the action of the chlorin on the various impurities in the water. If we take out these impurities by sedimentation basins we will have less trouble from taste and odor. At least that has been our observation so far.

As compared with the raw water that was used forty-seven years ago, when the public were not critical in regard to their water supply, great progress has certainly been made, but people have become intensely critical in regard to the quality of water that they use. It is proper that they should be and every effort would be made to give not only a safe but a desirable water.

Our plant should be studied with reference to the needs and conditions for a new plant which we will have to install in a few years. The study of the reactions of the chemicals used with reference to the various changes in the water during the different seasons will give us, we hope, sufficient data to use more scientific methods in the purification of water in our new plant. Professor Mortenson deserves great credit for the work he has done in studying and reporting in his valuable paper on "The Use of Hydrogen Measurements in Connection with the Purification of Water at Cedar Rapids."

MUNICIPAL WATER SOFTENING IN ILLINOIS¹

By A. M. BUSWELL²

An examination of the table (Water Survey Bull., 16, p. 77) shows that the majority (186) of the waters in Illinois have a hardness of from 300 to 600 parts per million. Only 1 water, from Mount Olive, has a hardness of less than 100, only 7 less than 200 and only 38 less than 300. Compared with the water supplies in the East these waters are extremely hard. For example, in Massachusetts only 16 well waters and one surface water used for municipal supplies have a residue of more than 200 parts per million. In Illinois, in addition to the waters already mentioned, 58 have a residue between 600 and 1000; 57 have a residue between 1000 and 2000; 11 between 2000 and 3000; 5 between 3000 and 4000; 1 between 4000 and 5000 and 1 has more than 5000.

Data were presented to show that either of two items would justify municipal water softening

1. The soap waste in a town of 40,000 inhabitants with a water of 300 p.p.m. hardness amounts to a ton per day.

2. The cost of operating pumps, cisterns and pressure pump for even 10 per cent of the population would probably pay for a municipal water softening plant.

The effect of hard water on the growth of a city is illustrated by two towns in the state where the water is exceedingly hard. These towns have had very little growth in the last twenty years, while other towns similarly situated but with better water supplies have grown rapidly.

The use of the very highly mineralized waters seems impracticable and an attempt should be made to obtain better waters if any are available.

¹ Abstract of paper before the Illinois Section meeting, March 22, 1923.

² The Chief, State Water Survey Division, Urbana, Ill.

DISCUSSION

Mr. T. N. VEATCH, JR.:³ Mr. Buswell's paper was one of the most instructive that it has been my pleasure to hear on the subject of municipal water softening.

The question of municipal water softening is constantly becoming of greater importance and is receiving more and more study on the part of water works officials and engineers as well as by the public generally. Water softening on a large scale by municipalities is not an experiment by any means, as the successful operation of such projects has been proved in quite a number of cases.

We have been connected with several municipal water softening plants in this section of the country, among them being the plants at Lawrence, Topeka and Manhattan, Kansas. In each case the public, from all appearances, is very much pleased with the results and does not regret the money spent in the improvements.

Dr. Buswell's paper outlines clearly the benefits to be derived from a soft water supply and it is my belief that water softening will be undertaken extensively, especially in regions where hard water is the rule rather than the exception.

A word of caution in connection with the subject of municipal water softening might not be amiss. In carrying on the campaign, which is almost always necessary to obtain funds for municipal softening plants, it is easy to make too elaborate claims in regard to the results that may be expected. There is a big question whether it is ever practical to try and produce a water with less than 130 p.p.m. of total hardness and certainly not less than 100 p.p.m. unless the town is largely made up of industries requiring soft water. There are cases, of course, where further softening might be justifiable and there are undoubtedly cases where the public might be educated to the point where they would gladly pay the cost of softening even to a greater extent, but, speaking generally, the public can be entirely satisfied with a water, say at least as soft as the Lake Michigan water, which I understand is about 130 p.p.m.

The plant at Lawrence, Kansas has been furnishing water ranging in hardness from 100 to 150 p.p.m. and the people have been very much pleased. For a time the supply was obtained from wells having a hardness of about 400 p.p.m. Later on the source of supply

³ Consulting Engineer, Kansas City, Mo.

was furnished from the Kansas River where the hardness varies from 200 to 400 p.p.m. depending on the stage of the river.

I have in mind the reaction that comes from "over selling" and I recall the elaborate claims that were once made by the advocates of the Cameron Septic Tank where the public was given to understand that, if the tank was installed, their troubles were ended forever. It has taken considerable education on the part of state departments and engineers to make the public realize that a sewage disposal plant really requires some attention. If care is used in presenting the question of municipal water softening, a general reaction may be avoided.

EFFECT OF THE NEW IMPOUNDING RESERVOIR ON FILTER PLANT OPERATION AT DECATUR¹

BY WM. E. STANLEY² AND E. E. RUTHRAUFF³

GENERAL

Decatur obtains a water supply from the Sangamon River through a pumping station and a filtration plant located on the north bank of the river near the Illinois Central Railroad in the southern part of the city. A pumping station was constructed on the site of the present station in 1871. The present pumping equipment was largely installed in 1911. The present filter plant was put into operation in September, 1914, and has not been extended.

At first the water supply was taken from an infiltration gallery near the river. About 1878 a small wooden impounding dam was constructed across the river, which dam was later replaced by a concrete structure and raised to elevation 595 forming a reservoir of approximately 30 million gallons capacity.

In 1920 the construction of the present impounding dam was started and completed during the summer of 1922. The impounding dam consists of a concrete spillway section approximately 500 feet long, having a crest elevation of 610 with provision for raising the effective crest by means of flash boards to elevation 612. At each end of the concrete section are earthen dykes with tops at elevation 623.

With the water level at 610 at the dam, the reservoir formed will extend approximately 13 miles upstream and has an estimated storage capacity of approximately 6 billion gallons, which is estimated to be sufficient to provide a minimum yield at the rate of 25½ million gallons per twenty-four hours. This reservoir has been named Lake Decatur and is rapidly becoming of considerable scenic interest to people in and outside of Decatur.

¹ Presented before the Illinois Section meeting, March 20, 1924.

² Engineer, Pearse, Greeley & Hansen, Chicago, Ill.

³ Chief Operator, Decatur Filtration Plant, Decatur, Ill.

A general plan showing the relative location of the reservoir and the city is shown in figure 1.

The impounding reservoir was completely filled first during March, 1922, before the dam was finished. It was necessary to empty the reservoir in order to close the dam and the reservoir was not again completely filled until early in March, 1923.

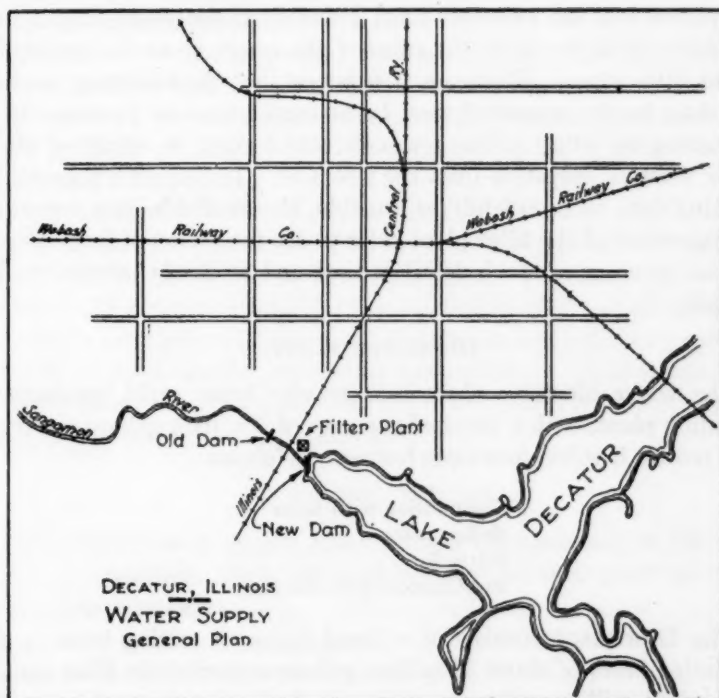


FIG. 1

Prior to the construction of the new impounding dam the storage reservoir was relatively small and probably had little effect upon the physical condition of the river water, except perhaps during periods of low flows in the summer seasons.

It is conceivable that the larger volume of water back of the new dam would have some appreciable effect upon the physical conditions of the river water and, consequently, upon the operation of the filter plant. The long, comparatively narrow body of water would tend to slow up the smaller flood flows and thus allow considerable of the

turbidity in the water to settle out before the water reaches the filter plant, and so decrease the load on the filter plant. On the other hand, large areas of the reservoir consist of shallow water which might tend to increase the load on the filter plant, especially during the summer seasons due to the growth of various microscopic organisms in the shallow and more or less stagnant waters.

The length of time which has elapsed since the new dam has been completed and the reservoir filled probably is too short to provide conclusive evidence as to the effect of the reservoir on the operation of the filter plant. However, it is hoped that the following operating data herein presented may be of some value as progress data indicating the effect of the reservoir, which may be amplified after a few years of operation from the reservoir. In line with presenting existing data as completely as possible, the available data covering the operation of the filter plant prior to the formation of Lake Decatur are given in as much detail as time and available records would permit.

FILTRATION PLANT

The water filtration plant is a gravity type, rapid mechanical filtration plant, with a nominal capacity of 9 million gallons per day. The process involves four main features, as follows:

- Coagulation with alum
- Sedimentation
- Filtration
- Sterilization with chlorine

The filter plant consists of a head house; a mixing basin; a coagulating basin of about 1½ million gallons capacity; six filter tanks, each of 1½ million gallons per day rated capacity, housed in a substantial filter house; and a filtered water reservoir with a total capacity of about 3 million gallons.

The filter building and head house form a single structure and are of concrete and brick construction with a slate roof. The remainder of the structures are of reinforced concrete.

The raw water is pumped to the filter plant by a set of two low lift pumps. As the water reaches the filter plant, it enters an influent well 9 feet by 20 feet 6 inches by 18 feet 6 inches deep, located beneath the headhouse. The coagulant is introduced into the water in this influent well. The water then flows through the mixing basin into the coagulating basins, thence to the filters.

The mixing basin consists of two parallel compartments each 83 feet long, 10 feet wide, and 18 feet 6 inches deep. One compartment contains vertical baffles which thoroughly mix the water. The two compartments provide a retention period of about twenty-five minutes at the rated capacity of the filter plant.

The coagulating basin consists of two sections which may be used either singly or together in parallel. To date, these sections have always been used together.

Sulphate of alumina is used as a coagulant. The alum solution is prepared in two concrete tanks, each with a capacity of 6000 gallons. A 5 per cent solution is made by charging each tank with 2450 pounds of alum. The alum solution feed is controlled by calibrated orifice boxes.

The amount of alum solution used for various conditions of turbidity and temperature of the raw water is regulated by observing the formation of the floc in the mixing basin. This method probably gives fairly accurate results for this particular plant, as all the plant operators have been with the plant since it was first put into operation, and have been careful with their observations. Rather complete records have been kept of the amount of alum used for various conditions of raw water and the results obtained.

OPERATING RECORDS

A complete daily record since starting the operating of the filter plant in September, 1914, has been kept by the filter plant operators of the following items:

- Pumpage
- Amount of wash water
- Alum
- Chlorine
- Turbidity of raw water
- Number of filters washed
- Length of wash
- Stage of river

A record of the following items has been kept for the period of time indicated:

Bacterial Analysis: Both raw water and filtered water daily since March, 1922, with occasional determinations prior to March, 1922.

Alkalinity: Daily records from March, 1922, to April, 1923, inclusive. Occasional observations for the remainder of the time.

Temperature of raw water: Daily records of temperature were kept for four years, 1916 to 1919 inclusive.

In addition to the records kept by the operators at the filter plant, analyses of the raw water and the filtered water have been made once a month by the State Water Survey Division, since 1916, and by the State Department of Public Health since 1920. These analyses give data on turbidity, color, odor, alkalinity, bacterial count, and the general sanitary condition of the water supply.

FILTER PLANT CAPACITY AND LOADINGS

The nominal capacity of the filter is 9 million gallons per twenty-four hours. The filtered water reservoir provides a storage capacity of approximately 3 million gallons. The monthly averages of daily water consumption steadily increased from an average of 3.5 m.g.d. in 1915 to a maximum monthly average of 8.1 m.g.d. in June, 1920 at which time the A. E. Staley Manufacturing Company put their own water supply into operation and the average monthly con-

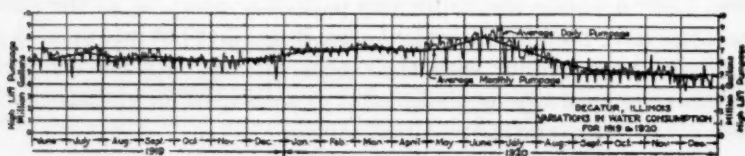


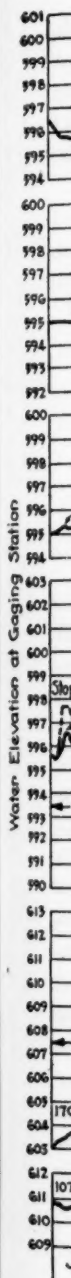
FIG. 2

sumption of city water dropped to 4 m.g.d. in April, 1921. Since April, 1921, the water demand has been steadily increasing to a maximum monthly average of about 6 m.g.d. during January, 1924.

During the period of maximum water demand in 1920, while the A. E. Staley Company were using such large quantities of city water, it was necessary to operate the filter plant at as much as fifty percent over capacity a great deal of the time. The average daily and average monthly pumpage rates for 1919 and 1920 are shown in figure 2.

CHARACTER OF THE RIVER WATER

The raw water supply is pumped directly from the river impounding reservoir to the filter plant. The Sangamon River is the largest tributary of the Illinois River and has a total drainage area above Decatur of about 862 square miles.



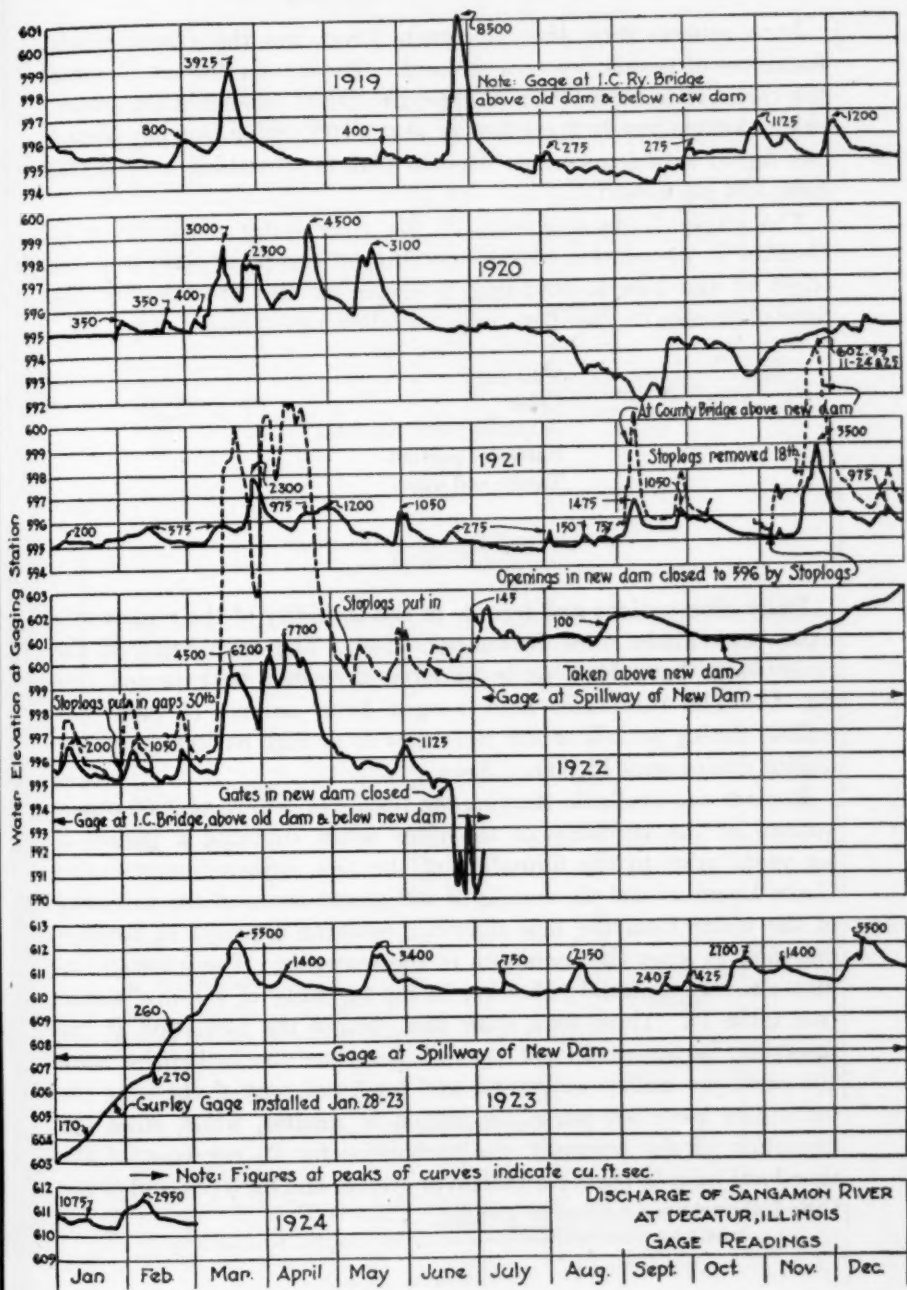


FIG. 3

In a general way, the Sangamon River has the characteristic flashiness of middle western streams. The stream flow at Decatur has varied from a minimum of approximately 7 cubic feet per second to an average yearly flood flow of about 7000 cubic feet per second (see fig. 3) with a maximum flood in 1913 of something over 18,000 cubic feet per second.

The physical characteristics of the river water as observed at Decatur in its relation to the operation of the filter plant and the effect of the new impounding reservoir on the operation of the filter plant may be classified under the following headings:

Turbidity
Color
Alkalinity and hardness
Bacterial content
Tastes and odors

Turbidity

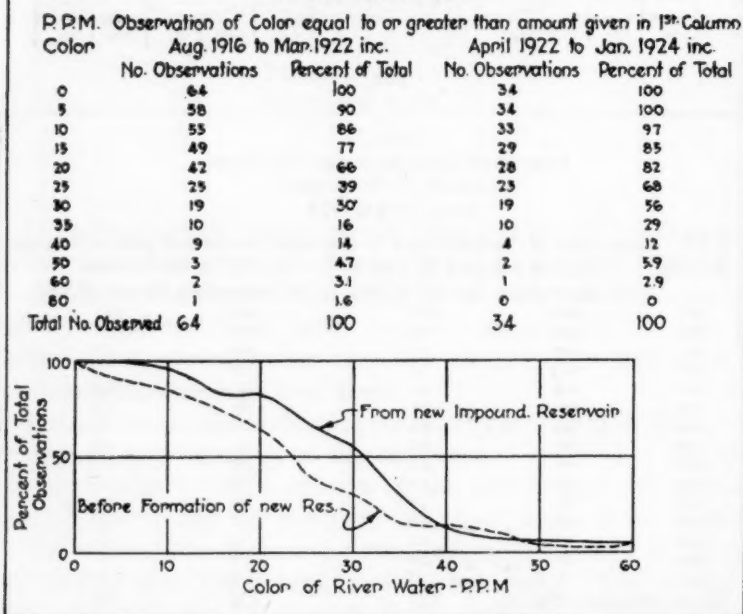
Daily observations and records of the turbidity of the river water have been made since November, 1914. The turbidities of the river water have been quite variable as would be expected (see fig. 4). The turbidities have ranged from around 15 parts per million during periods of low river flow to as high as 5000 parts per million during some high flood flows.

Records are available showing the results of a total of 2256 observations of the turbidity of the river water covering a period of six years prior to the formation of the new impounding reservoir (Lake Decatur) and the results of 639 observations of the turbidity of the water from the new reservoir covering a period of twenty-one months since the formation of the reservoir. These results indicate a very material reduction in the turbidity of the raw water. (see table 1). These data show that, before the formation of the reservoir, for about 25 per cent of the time the turbidities were 100 parts per million or greater and for 5 per cent of the time the turbidities were 500 parts per million or greater, while, since the formation of the reservoir, the turbidities for 25 per cent of the time have been 50 parts per million or greater and for 5 per cent of the time 150 parts per million or greater.

Color

Observations of the color of the raw water have been made approximately once a month since 1916 by the State Water Survey Division and approximately once a month since 1920 by the State Department of Public Health. These observations show a range from no color to a color of 80 parts per million, before the formation of the

Table 2
Filter Plant Operation at Decatur, Illinois
Color of River Water
Period 1916 to 1924



impounding reservoir and a range of from 5 to 60 parts per million since the formation of the reservoir. The observations of color before and after the formation of the impounding reservoir indicate an increase in color ranging from 10 to 30 per cent (see table 2). It is likely that this increase in color is largely due to decaying vegetation as the reservoir site was not stripped before filling, and that the amount of color will decrease somewhat with time.

Alkalinity and Hardness

Determinations of the alkalinity of the raw water were made at the filter plant daily from March, 1922, to April, 1923, and occasionally during the remainder of the period of the operation of the filter plant. Additional observations have also been made approximately once a month by both the State Water Survey Division and the State Department of Public Health.

The alkalinity ordinarily runs about 250 parts per million. However, there are considerable variations in alkalinity with variations

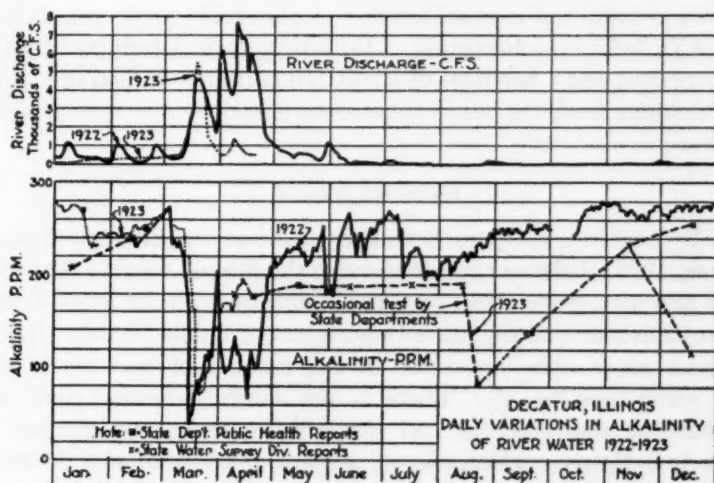


FIG. 5

in the flow of the river (see fig. 5) and a few times during large floods, the alkalinity has dropped as low as 40 parts per million, so low that there was an insufficient amount to coagulate the water properly without addition of lime. The observations of alkalinity have been too few to indicate any very definite effect of the reservoir on the alkalinity. It is likely that the reservoir will tend to stabilize the alkalinity and prevent it dropping so low as to necessitate the use of lime at the filter plant.

Only a few determinations of the hardness of the raw water have been made. The recorded results of hardness determinations are as follows:

DATE	HARDNESS (Ca CO ₃)	REMARKS
	p. p. m.	
December, 1920.....	136	Determined by soap method
January, 1921.....	151	Determined by soap method
February, 1921.....	128	Determined by soap method
March, 1921.....	126	Determined by soap method
April, 1921.....	126	Determined by soap method
May, 1921.....	124	Determined by soap method
January, 1924.....	189	Determined by soda reagent method
February, 1924.....	166	Determined by soda reagent method

These results indicate a hardness of about 130 parts per million of CaCO₃ before the formation of the reservoir as determined by the soap method and a hardness of about 170 parts per million of CaCO₃ of the water from the reservoir as determined by the soda reagent method.

Bacterial content

Daily bacterial analyses have been made at the filter plant since March, 1922, of the raw water and also the filtered water. Analyses have also been made about once per month by both the State Water Survey Division and the State Department of Public Health. These analyses show wide variations in the number of bacteria in the raw water (see fig. 6). There is not much indication that the impounding reservoir has had much influence on the number of bacteria in the river water, except, perhaps, the first few months while the reservoir was filling. However, the number of the observations are too few to give decisive indications.

Tastes and odors

Unfortunately little record has been kept of the growth of microscopic organisms in the river water before and after the formation of the new reservoir. Observations of odors have been made about once a month, as a routine part of the analysis by the State Water Survey Division and also by the State Department of Public Health.

Considerable trouble with bad tastes and odors in the filtered water was experienced the later part of January and the first part of February, 1923. These tastes and odors were attributed to *Synura* in the impounding reservoir. The disagreeable tastes and odors were reduced to some extent by using an excess of alum and chlorine

in the filtration of the water. A total of approximately 16,000 pounds excess alum was used during a period of one month or an average of about 104 pounds per million gallons of water filtered.

Chemical treatment

The chemicals used at Decatur are sulphate of alumina or alum used as a coagulant in the clarification of the raw water and chlorine used for sterilization of the filtered water, as it goes from the filter plant to the high lift pumps.

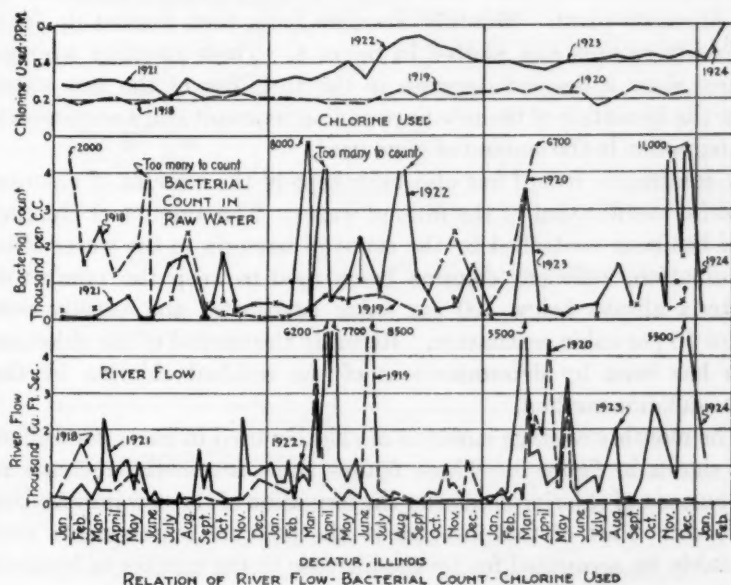


FIG. 6

The experience at Decatur indicates that the amount of alum required to clarify properly the raw water depends largely upon the turbidity and the temperature of the raw water, although other factors such as the color and the microscopic organisms have been observed to affect materially the amount of alum required at times, usually during periods of heavy rain fall in the fall of the year.

Daily records of the turbidity and temperature of the raw water, and the amount of alum used were kept for the four years, 1916 to 1919, inclusive. These data have been classified so that the observa-

tions are divided into classes as to turbidity and temperature of the raw water. The results of these classifications are given in figure 7. These data indicate an increase in the amount of alum required when the temperature of the raw water is from 0 to 5°C. over the amount of alum required when the temperature of the water is from 25 to 30°C. of about 25 per cent for average turbidities of 50 parts per million and 100 per cent when the turbidities are 200 to 400 parts per million.

Daily records have been kept of the turbidity of the raw water and the amount of alum used for the entire period of operation of the filtration plant. Monthly averages have been worked up from the daily records and plotted in figure 8. These monthly average figures show a decided decrease in the turbidity of the raw water after the formation of the new impounding reservoir and a corresponding reduction in the amount of alum used.

A continuous record has also been kept of the amount of chlorine used for sterilization of the filtered water. The amount of chlorine used has been controlled by the count of bacteria in the water after chlorination, sufficient chlorine being used to keep the number of bacteria always below 100 per cubic centimeter and usually well below 50 per cubic centimeter. Recently the control of the chlorination has been by determinations of the residual chlorine by the ortho-tolidine method.

The monthly average amounts of chlorine used in parts per million are shown in figure 8. These figures show a material increase in the amount of chlorine used after the formation of the new impounding reservoir. Part of this increase in the chlorine requirements may probably be accounted for by the increase in the number of bacteria in the raw water (see figure 6). The larger part of the increase in the chlorine requirements, however, is probably due to decreased efficiency of the filter beds.

The filter beds were originally constructed with 9 or 10 inches of graded gravel and 30 inches of silica sand from Ottawa, Illinois. The sand had an effective size of 0.32 m.m. and a uniformity coefficient of 1.81 when put in the filters in 1914. Since the plant has been in operation, the thickness of the sand beds has been reduced to about 24 inches by losses in washing and cleaning the beds and the size of the sand grains has been enlarged by a coating of iron and manganese. An analysis of the coating in 1921 by the State Department of Public Health showed that it contained 0.9 per cent of

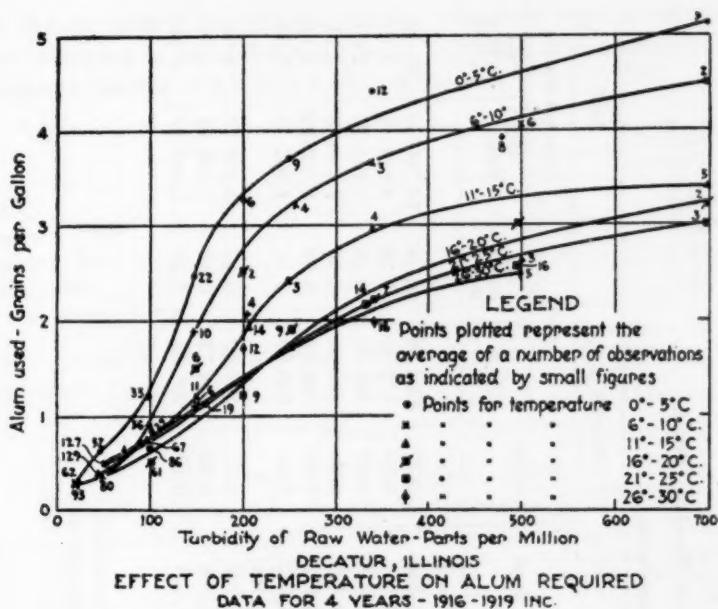


FIG. 7

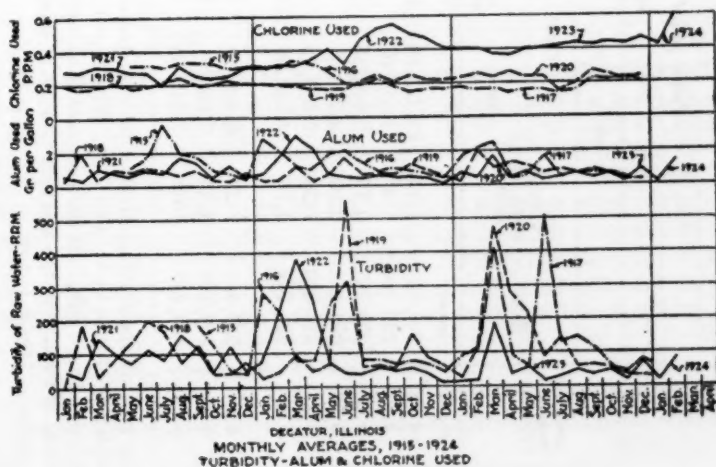


FIG. 8

TABLE 3
Filter plant operation at Decatur, Illinois
Cost of chemicals

YEAR ENDING HIGH LIFT PUMPAGE APRIL 30	ALUM				CHLORINE				COST*	
	AVERAGE HIGH LIFT PUMPAGE	Total pounds	Average grams per gallon	Cost*		Total pounds	Average† p.p.m.	Cost*		Alum and chlorine Total
				Total	Per million gallons			Total	Per million gallons	
1916	4.08	367,705	1.74	\$3,475.79	\$2.33	11,540	0.32	\$224.06	\$0.16	\$3,700.85
1917	4.91	359,200	1.37	4,419.07	2.46	8,691	0.19	472.20	0.26	4,891.27
1918	5.25	208,215	0.72	3,669.35	1.85	9,318	0.19	351.58	0.18	4,013.93
1919	5.63	203,668	0.69	3,757.01	1.83	10,435	0.20	379.80	0.18	4,136.19
1920	6.47	416,483	1.20	7,540.63	3.19	13,913	0.23	525.63	0.22	8,066.26
1921	5.63	224,374	0.76	4,242.29	2.07	2,802}†	0.20	626.90	0.31	4,869.19
1922	4.85	334,316	1.29	6,228.12	3.52	4,204	0.27	578.40	0.32	6,806.52
1923	5.27	169,794	0.57	2,657.88	1.38	6,998	0.42	768.75	0.40	3,426.63
1924§	5.74	150,910	0.69	2,147.63	1.41	7,476	0.57	901.54	0.58	3,049.17

* Includes cost of chemicals delivered in filter plant.

Hypo-chlorite of lime used until July, 1920, liquid chlorine thereafter.

† Free chlorine based upon 33½ per cent free chlorine in hypo-chloride used.

‡ 802 pounds of hypo-chloride and 3162 pounds of liquid chlorine were used.

§ Ten months to March 1, 1924.

iron, 0.1 per cent of manganese, and the remainder organic material. Sieve analyses of the filter sand since 1920 indicate a progressive increase in the size of the sand grains, as follows:

DATE	EFFECTIVE SIZE	UNIFORMITY COEFFICIENT
1914.....	0.32	1.81
February, 1921.....	0.44	1.14
February, 1923.....	0.56	1.13
March, 1924.....	0.57	1.13

Arrangements are now being made at Decatur to replace the filter sand.

TABLE 4

Filter plant operation at Decatur, Illinois
Total annual operating cost of filter plant

YEAR ENDING APRIL 30	AVERAGE HIGH LIFT PUMPAGE	COST OF CHEMICAL	WASH WATER		ATTENDANTS AND MISCELLANEOUS LABOR†	SUPPLIES AND REPLACEMENTS	STEAM HEAT	TOTAL COST OF OPERATION	
			Million gallon used	Cost‡				Total	Per million Gallons
	m. g. d.								
1915*	3.58	\$1,944.48	10.42	51.21	\$2,930.00	\$5.00	\$722.64	\$5,653.33	\$6.46
1916	4.08	3,700.85	21.45	107.25	4,370.00	10.00	1,084.05	9,272.15	6.22
1917	4.91	4,891.27	27.23	136.15	4,570.00	135.00	1,084.05	10,816.47	6.03
1918	5.25	4,013.93	25.57	127.85	5,570.00	10.00	1,084.05	10,805.83	5.63
1919	5.63	4,136.19	25.83	129.15	4,670.00	12.00	1,084.05	10,031.39	4.89
1920	6.47	8,066.26	35.72	178.60	4,370.00	15.00	1,084.05	13,713.91	5.80
1921	5.63	4,869.19	32.12	160.60	4,550.00	880.00	1,084.05	11,543.84	5.63
1922	4.85	6,806.52	33.10	165.50	4,550.00	15.00	1,084.05	12,621.07	7.13
1923	5.27	3,426.63	39.30	196.50	4,730.00	1,410.00*	1,084.05	10,847.18	5.63
1924§	5.74	3,049.17	34.53	172.75	4,540.00	8.00	903.30	8,673.22	4.97

* Eight months September, 1914, to April 30, 1915.

† Based on estimated cost of low pumpage and steam for wash water pump.

‡ Miscellaneous labor for cleaning basins and work about plant estimated at \$50 per year.

§ Ten months ending February 29, 1924.

|| Wallace and Tiernan chlorinator replacing hypo tanks.

* First chlorinator repaired (\$300) new vacuum type machine added.

OPERATING COSTS

A record has been kept since 1915 of the amount of alum and chlorine used and the cost of each delivered at the filter plant. These data, given in table 3, show that the total cost of chemicals has materially decreased since the formation of the new reservoir.

The total annual costs of operating the filter plant are given in table 4.

The total operating costs have ranged from \$7.13 for the year ending April 30, 1922 to \$4.97 per million gallons for the ten months ending Feb. 29, 1924. The reduction in the cost of chemicals has been \$3,800 or \$1.85 per million gallons of water filtered.

SUMMARY AND CONCLUSIONS

The data available to date covering the operation of the filter plant at Decatur before and after the formation of the new impounding reservoir indicate that the reservoir is a material benefit in reducing the load on the filter plant.

SOCIETY AFFAIRS

THE ANNUAL CONVENTION

The American Water Works Association opened its forty-fourth annual convention at the Hotel Astor, New York City, during the week of May 19, 1924.

Monday, May 19, was spent in registration of members, meetings of executive committees and special committees, and round table discussions on superintendent's topics, coöperation between water works and fire protection men, standard methods of water analysis, loadings for purification processes, colloid chemistry, data for water records and purification of boiler waters.

On Monday evening a testimonial dinner was held for members and guests in honor of J. M. Diven, who retired as Secretary after twenty-two years of service. The dinner was marked by great enthusiasm in demonstrating the respect and love for an official whose untiring activities for the Association during such a long period were the source of much comment. At a later meeting of the Executive Committee Mr. Diven was made Secretary Emeritus and an honorary member of the Association.

The opening session of the convention was called to order by President Fuller at 9:30 a.m. on Tuesday, May 20. With no opposition ticket the chair instructed Acting Secretary Diven to read the list of officers elected for the ensuing year: President, Frank C. Jordan; Vice-President, Harry F. Huy; Treasurer, William W. Brush; Director, J. Arthur Jensen.

Secretary Diven then read the report of the executive committee, including a summary of the report of the secretary and the treasurer.

Chairman Fuller announced that contracts had been let for the publication of the "Manual of Americal Water Works Practice" and that the Association was about to coöperate with the Public Health Association for the publication of "Standard Methods of Water Analysis."

Three honorary members were unanimously elected, as follows: H. E. Keeler, John M. Diven and Clemens Herschel.

Several important changes in the constitution of the association were brought before the convention. These were read by the secretary, article by article, and each one was voted upon separately. All were carried. These changes appear in the September Supplement to the JOURNAL.

Nicholas S. Hill, Jr., reported for the Committee on Private Fire Protection Services that it had been inoperative for some two years.

Edward E. Minor, of the representatives on the American Committee on Electrolysis, reported that a great good had been accomplished by the American Committee by bringing together those who suffered from the trouble of electrolysis and those who caused these troubles.

Mr. Fuller said that the association would work with the Committee on Electrolysis provided that no funds were taken from the treasury. The report of the committee was approved and it was continued. Seth M. Van Loan reported progress for the committee on Standard Specifications for Water Meters.

The Committee on Standard Form of Contract was reported for by John M. Goodell, its secretary. He said that the last convention of the Association approved for trial a contract provided by the Association and other organizations. The committee submitted a number of recommendations and other associations made further suggestions. During the year Messrs. Waldo Smith, Chester and Davis attended conferences. The committee has revised slightly the form of contract, with all recommendations of the Association accepted. The printing of the document has not yet been completed. The committee was continued.

President Fuller reported for the Standardization Council. He emphasized the necessity for the proper discussion by the members of the convention, of the various committee reports, so that the council may know the views of the members on the subject.

The first paper of the session was by L. P. Wood on Allocation of Water Supply Derived from Water Sheds of Interstate Streams.¹ Discussion by J. W. Smith and M. Knowles.

It was followed by Iodine Treatment of the Rochester Water Supply,² by Beekman C. Little; discussion by M. Tolman, J. J. Hinman, Jr., J. W. Ellms, S. G. Highland and G. C. Whipple.

¹ Journal, May, 1924, page 521.

² This Journal, page 68.

On the opening of the afternoon session the members decided to petition for the formation of a Fire Protection Division. This Division was later approved by the Executive Committee.

The following papers were presented: The Method of Making Flow Tests and Their Value to the Water Works Engineer, by George W. Booth. The Relation of Fire Protection Requirements to the Distribution System of Small Towns, by C. Goldsmith. The Economic Significance of the Fire Waste, by F. H. Wentworth.

Mr. Jordan at this point called for nominations for officers of the Fire Prevention Division.

Frank A. Barbour nominated the following, who were unanimously elected. Chairman, Nicholas S. Hill, Jr.; Vice-chairman, Allan W. Cuddeback; Secretary-treasurer, Clarence Goldsmith.

Mr. Jordan retained the chairmanship of the meeting. He called upon V. Bernard Siems, who read his paper on Fire Flow to be Provided in Large Cities under Various Conditions of Risk.³ This paper was followed by a paper by Louis Stockmeir on Effect of Distribution System Design upon the Fire Insurance Rates.⁴

This group of papers was discussed by J. H. Howland, George W. Booth, William Luscombe, Abel Wolman and several others.

At five o'clock the chair called for nomination by districts for members of the nominating committee. Several of the districts were not ready to report their candidates.

Those who had decided on candidates were District No. 2, New England States, Stephen H. Taylor, New Bedford, Mass.; No. 3, New York, Frederick E. Beck, Utica, N.Y.; No. 5, V. Bernard Siems, Baltimore, Md. The meeting then adjourned.

The evening session was under the auspices of the Water Works Manufacturers' Association. John F. Reagan, president of the Manufacturers' Association, presided. The first paper by Alan Johnstone was on What Water Really Is. The second paper was by W. L. Egy, on The Development and Manufacture of Engineering and Surveying Instruments. These were followed by Progress in the Chemistry of Precipitation and Coagulation, by H. M. Spencer; The Development and Manufacture of the Modern Cement-Lined Service Pipe, by R. J. Newsom; Observations On the Chlorination of Small Water Supplies, by M. J. Tiernan.

³ Journal, January, 1924, page 17.

⁴ Journal, May, 1924, page 572.

A card party was given to the ladies of the convention, under the auspices of the Water Works Manufacturers' Association, in charge of the Ladies' Entertainment Committee.

Morning session, May 21. Presiding officer, President Fuller.

The nominations for the nominating committee as completed by the various districts were as follows: No. 1—O. D. Brown, Walkerville, Ont.; No. 2—Stephen H. Taylor, New Bedford, Mass.; No. 3—Fred Beck, Utica, N. Y.; No. 4—G. C. Gensheimer, Erie, Pa.; No. 5—V. Bernard Siems, Baltimore; No. 6—John W. Toyne, South Bend, Ind.; No. 7—L. B. Mangun, Kansas City, Kan.; No. 8—H. E. Keeler, Chicago; No. 9—W. W. Hurlburt, Los Angeles, Cal.

All were unanimously elected.

The new trustees are: District No. 1, Alexander Milne, St. Catharines, Ontario; No. 4, Edgar M. Hoopes, Jr., Wilmington, Del.; No. 5, J. E. Gibson, Charleston, S. C.; No. 8, J. A. Jensen, Minneapolis, Minn., and District No. 9, F. M. Randlett, Portland, Ore.

The first report was by Chairman S. T. Powell, of Standardization Committee No. 11 on Sanitary Fountains.⁵ The report was accepted and the committee discharged.

At this point the chair introduced C. N. Avery, Chairman of the Texas Water Works Association, who addressed the convention. Mr. Avery hoped the Texas Association would soon become a division of American Water Works Association. He expressed his appreciation of the courtesies extended to him by the members.

The next committee to report was No. 2 of the Standardization Council on Standards for Satisfactory Drinking Water. The report was presented by Abel Wolman for Dr. Allen W. Freeman. Dr. A. J. McLaughlin spoke on the administrative control of water supplies by the United States Public Health Service.

George C. Whipple, read a paper on Government Requirements and Professional Standards.⁶

The report and paper were freely discussed by H. E. Jordan, F. E. Hale, Jack J. Hinman, Jr., J. W. Ellms, Edward Bartow, William Gore, Norman J. Howard, Abel Wolman and several others.

At 12 o'clock, as a special order of business, the selection of the next place of meeting was taken up. The chair appointed as tellers Dennis O'Brien, W. S. Cramer and John N. Chester. Acting

⁵ Journal, March, 1924, page 483.

⁶ This Journal, page 61.

Secretary Diven read the list of cities recommended by the executive committee as eligible in the order of their choice.

The executive committee recommended a number of cities which had applied for the convention next year, but this was narrowed down to Louisville, Ky.; Atlanta, Ga.; Baltimore, Md.; and Milwaukee, Wis. Louisville was chosen as the convention city for 1925.

The session then adjourned.

Afternoon session, May 21. Presiding officer, President Fuller.

The first paper of this session was on Large Water Supply Mains⁷ by Dabney H. Maury; discussion by G. W. Fuller, N. S. Hill, Jr., E. G. Ritchie, C. B. Burdick, W. Gore, W. W. Brush, L. P. Wood, J. E. Gibson, T. A. Leisen, G. J. Requardt and D. H. Maury.

T. A. Leisen described methods of cleaning the Omaha sedimentation and coagulation basins.

It was announced that W. S. Cramer had been elected as chairman and J. M. Diven as secretary of the Plant Operation and Management Division.

The session adjourned.

The ladies of the convention were entertained at 8 p.m. by a performance at the Hippodrome. At ten o'clock the men were given a smoker in the Roof Belvedere of the Hotel Astor. Both were given through the courtesy of the Water Works Manufacturers' Association.

Morning session, May 22. Presiding officer, President Fuller.

Thaddeus Merriman spoke on Arrangement for Preventing Pollution of the Catskill Water Supply.

This paper was followed by the report of Committee No. 5, on Watershed Protection,⁸ W. L. Stevenson, chairman. This report was discussed by C. A. Holmquist, W. W. Brush, C. B. Mark, Ivan M. Glace, L. D. Matter, J. W. Fortenbaugh, C. L. Siebert, J. H. Bridgers, Robert S. Weston and others.

The next report discussed was on Industrial Wastes in Relation to Water Supply.⁹ Almon L. Fales, as chairman of the committee, gave a brief summary of the report, which was discussed by H. E. Moses, E. S. Tisdale, J. W. Ellms and C. A. Emerson, Jr.

⁷ This Journal, page 1.

⁸ Journal, May, 1924, page 613.

⁹ Journal, May, 1924, page 628.

At this point Mr. Fuller turned the convention over to the new president, F. C. Jordan.

The final committee to report for the session was No. 12, on Testing of Water Works Materials and Supplies,¹⁰ T. H. Wiggin, chairman. The report was discussed by Thaddeus Merriman, A. D. Flinn, L. P. Wood, F. W. Green and John R. Baylis.

At 1 o'clock the entire convention embarked upon the "Onteora" and were taken for a sail on the Hudson River, landing at Bear Mountain at about 4:30. At 5:30 an excellent dinner was served in the Bear Mountain Inn, with an orchestra and song leader to enliven the occasion. The trip was under the auspices of the Water Works Manufacturers' Association and in direct charge of William C. Sherwood and Theodore R. Kendall.

Morning session, May 23. Presiding officer, G. W. Fuller.

Action of Water on Service Pipe¹¹ by Wellington Donaldson was the first paper presented as contribution to the work of Committee No. 10.

The report of Committee No. 10, Standardization of Services, by J. M. Diven, followed. This report was discussed by F. N. Speller, Robert S. Weston, David Heffernan, G. C. Whipple and W. Donaldson.

The report of Committee No. 7, Pumping Station Betterments, by Leonard A. Day, chairman, was followed by a paper on Operating Experiences and Economy of a Diesel Engine Driven Pumping Station, by P. deW. Vosbury; discussion by John N. Chester, L. A. Day, Kerr, P. Vosbury and R. D. Hall.

Afternoon session, May 23.

The final session of the convention was well attended and was marked by lively discussion on several important topics of interest to superintendents. James E. Gibson was in the chair.

Among the questions debated were the matter of distributing the purchase of pipe over the year so as to relieve the congestion in the pipe foundries.

George R. Taylor told of an experience with Synura and other water-borne organisms and his methods of using copper sulphate when his reservoir was covered with ice. This was discussed by F. C. Dugan and J. E. Gibson.

Use of the flushometer was discussed by J. M. Diven, D. H. Heffernan and S. L. Mosely.

¹⁰ Journal, May, 1924, page 663.

¹¹ Journal, May, 1924, page 649.

The use of pipe jointing compounds was discussed by J. M. Diven, C. A. Spencer, R. C. Wilson and W. H. Buck.

Leak detecting instruments were discussed by L. E. Moore, F. Henshaw, D. H. Heffernan, H. B. Foote and J. E. Gibson.

The question of changing meters in testing them and the best method of keeping track of the meters was discussed by H. B. Foote, J. E. Gibson, J. G. Valentino, H. T. Gidley and F. Henshaw.

Fire protection services were discussed by Harry A. Burnham, J. M. Diven, H. B. Foote, W. H. Buck and J. E. Gibson.

Water shortage was discussed by J. E. Gibson, O. E. Bulkeley, J. M. Diven, J. G. Valentino and others.

The question of extensions brought up the installation of service connections in vacant property, which was discussed by J. G. Valentino, D. H. Heffernan, J. N. Chester, T. R. Duggan and J. M. Diven.

Chemical and Bacteriological Division. At 2:00 p.m., May 20, the Chemical and Bacteriological Division met in the Laurel Room, with A. L. Fales, Chairman, presiding. The progress report of the Committee on Standard Methods of Water Analysis was made by its chairman, Jack J. Hinman, Jr., and was very freely discussed by R. C. Bardwell, A. M. Buswell, L. H. Enslow, C. R. Knowles, J. W. Ellms, L. I. Birdsall, H. G. Dunham, M. McCrady, H. E. Jordan and N. J. Howard. This was followed by several papers, as follows: "A Defect in Permanent Color Standards due to Variations in Cobalt Chloride," by M. C. Whipple; "Color Transmittancy Curve by Some of the Colorimetric Standards including Cobalt Chlorides," (illustrated with lantern slides) by A. M. Buswell; "Micro Dissolved Oxygen Apparatus," (with demonstration) by A. M. Buswell; "Note on the Use of Dyes in Agar Media," by Max Levine; "Use of Gentian Violet Broth," by Jack J. Hinman, Jr.; "A Note on the Voges Proskauer Reaction," by C. S. Linton; and "Organization and Program of Sewage Investigations by the New Jersey Argicultural Experiment Station and the State Department of Health," by William Rudolfs.

The session was largely attended and the discussions of the papers were both general and extensive.

The second session of the Chemical and Bacteriological Division met at 2:00 p.m., on May 21. The first order of business was the report of Committee No. 18, Filter Sand Testing and Recording, of which Paul Hansen is Chairman. Discussion of this report was by F. H. Waring, Abel Wolman and John R. Baylis. Committee

No. 3, Practicable Loadings for Purification Processes was next reported for by S. M. Van Loan. Discussion was by Abel Wolman, S. M. Van Loan, W. Donaldson, H. W. Streeter and F. H. Waring.

An interesting discussion was held on "The Most Interesting Experience I Have Recently Encountered in Water Treatment." This was opened by J. W. Armstrong, and those who spoke were J. R. Baylis, W. R. Gelston, A. V. Graf, F. W. Green, C. R. Henderson, C. P. Hoover, N. J. Howard, H. W. Jordan, M. C. Whipple, L. H. Enslow, and A. M. Buswell.

A dinner for the members of the Chemical and Bacteriological Division was held on Wednesday evening, May 21, in the South Gardens on the tenth floor of the hotel. The toastmaster of the dinner was Almon L. Fales. Mr. Fales first called upon President Fuller and the latter made a long address outlining some suggestions as to the future of the division. Mr. Fuller, among other matters, spoke of the idea of changing the name of the Division to a more comprehensive title and suggested that of "Water Purification and Control Division."

The next speaker was the incoming president, Frank C. Jordan, who outlined his policy and spoke of what he hoped to accomplish for the convention and for the division during the coming association year.

The chairman followed the plan of calling upon the members during the dinner and between courses instead of waiting until the end, and there were a large number of addresses given. Among the speakers were Harry E. Jordan, Jack J. Hinman, Jr., F. W. Green, Malcolm Pirnie, H. Burdette Cleveland, Robert S. Weston, Paul Hansen, J. M. Goodell, George C. Whipple, A. M. Buswell, N. J. Howard and John R. Baylis. The speaking continued until a late hour.

Friday Morning, May 23. Presiding officer, A. L. Fales. The following papers were presented:

"Characteristic Properties of Zeolites for Water Softening," by S. B. Applebaum.

"The Early History of Zeolites," by A. S. Behrman.

Both papers were discussed by A. M. Buswell, L. M. Yoder, J. R. Baylis, S. B. Applebaum and A. S. Behrman.

"Adsorption of Aluminum Hydrate," by L. B. Miller.

The Division was then addressed by President Fuller on the organization and function of the Division in the Association.

Considerable discussion took place on the program of work of Committee No. 1 on Standard Methods of Water Analysis.

W. S. Cramer addressed the Division on the general thought of extending cooperation from the Division of Plant Management and Operation.

In the absence of any opposition, the following officers, suggested by the Nominating Committee, were elected: A. M. Buswell, Chairman; J. W. Armstrong, Vice-Chairman; J. J. Hinman, Secretary; R. C. Bardwell and C. P. Hoover, Executive Committee Members. The decision as to a change in the name of the Chemical and Bacteriological Division was deferred until the next annual convention.

THE HILL CUP FOR MEMBERSHIP

North Carolina retains the Hill Cup, as this section showed by far the greatest percentage of increase in membership for the year ending May 21, 1924. Certain records were lost when the office of the Association moved to its new quarters. North Carolina, however, has by far the greatest increase. Their percentage of increase approximated 87, with the Iowa Section second with 36, and California third with 34.

ABSTRACTS OF WATER WORKS LITERATURE

FRANK HANNAN

Key: American Journal of Public Health, 12: 1, 16, January, 1922. The figure 12 refers to the volume, 1 to the number of the issue, and 16 to the page of the Journal.

War Department Turns to Fuel Oil. W. W. BOWMAN. *Power*, 58: 9, 327, August 28, 1923. Three 4400 sq. ft. boilers were converted from coal to fuel oil. This necessitated installation of oil-storage tanks, pumps, and piping; a change in the boiler setting and baffling, and installation of fuel-oil burning equipment. Official acceptance test showed exceptionally low draft required; economically low flue-gas exit temperature; and high gross and net boiler, and furnace efficiency, well sustained over wide range of operation.—*Aug. G. Nolte.*

Questions and Answers. FRANKLIN VAN WINKLE. *Power*, 58: 9, 342, August 28, 1923. Questions are asked and answers given on following subjects,—Position and Durability of Boiler Patches; Steam Valves of Duplex Pumps Without Lap or Lead; Overheated Main Bearing; Hammer Test of Boiler; Cause of High Head Pressure; Percentage of CO₂ for Best Efficiency; Removal of Gas from Well Water; Averaging Readings of Spring Pressure Gage; Cushion of Steam Pump; Negative Lead of Valve.—*Aug. G. Nolte.*

Periodic Power-Plant Inspection. *Power*, 59: 11, 404, March 11, 1924. The Federal Light and Traction Co., New York City, have issued general instructions to managers of their subsidiary companies for a yearly inspection of all power-station apparatus. A partial list of units to be inspected, for each of which required observations are stated, follows—Turbo-Generator Units; Condensers; Boilers, Stokers and Furnaces; Reciprocating Engine Generator Units; Feed Water Heaters; Water Softeners and Tanks; Cooling Water Facilities; Auxiliaries; Steam and Water Piping; Instruments and Switch-Board Equipment.—*Aug. G. Nolte.*

Largest Two-Stroke-Cycle Diesel Built in America. *Power*, 59: 11, 406, March 11, 1924. Description of the Bethlehem 2900-horsepower Diesel engine.—*Aug. G. Nolte.*

Questions and Answers. FRANKLIN VAN WINKLE. *Power*, 59: 11, 422, March 11, 1924. Questions are asked and answers given on following subjects: Relative Advantages of Bevel and Flat Seats for Safety Valves; Furnace Volume for Pulverized Coal and for Fuel Oil; Additional Pressure for Increased

Temperature of Air; Unreliability of Distorted Bourdon Gage Tube; Operating Alternator Without Direct-Current Excitation; Boiler Plant Output per Pound of Fuel; Greater Range of Cutoff with Double-Eccentric Engine.—*Aug. G. Nolte.*

Typhoid Fever in the Large Cities of the United States, 1923. Public Health Reports, 39: 8, 349, February 22, 1924. Taken from issue of February 2, 1924, Jour. Amer. Med. Assocn. Statistics of 69 cities that had more than 100,000 population in 1920. Slight typhoid reduction shown in 1923 as compared with 1922. Average death rates per 100,000 from typhoid fever for these cities for the years 1920, 1921, 1922 and 1923 were, respectively, 3.7, 4.0, 3.3 and 3.2. Average death rate per 100,000 for same cities arranged in groups according to population, follow. Group 1, population more than 500,000 (12 cities), rate 2.5; Group 2, population 300,000 to 500,000 (9 cities), rate 3.8; Group 3, population 200,000 to 300,000 (12 cities), rate 4.1; Group 4, population 150,000 to 200,000 (10 cities), rate 6.7; Group 5, population 125,000 to 150,000 (9 cities), rate 2.8; Group 6, population 100,000 to 125,000 (17 cities), rate 4.2. Norfolk, Va., included in last group, had honor of being only city among the 69 without a death from typhoid fever during 1923. Actual percentage reduction of typhoid has slowed up; but improvement in many cities is still taking place. Rural typhoid must now be eradicated.—*Aug. G. Nolte.*

Spring Water of Unusual Composition. R. T. THOMPSON AND JAMES SORLEY. Analyst, 49: 82-3, February, 1924. A spring water from a wood near Glasgow contained $\text{Al}_2(\text{SO}_4)_3$, 38.1 p.p.m.; FeSO_4 , 0.1 p.p.m.; CaSO_4 , 17.2 p.p.m. MgSO_4 , 10.7 p.p.m.; MgCl_2 , 6.1 p.p.m.; NaCl , 25.9 p.p.m.; NaNO_3 , 0.4 p.p.m.; SiO_2 , traces; organic matter, 6.0 p.p.m.; total, 104.5 p.p.m. It contained 0.07 p.p.m. albuminoid NH_3 ; and 0.05 p.p.m. free NH_3 .—*Jack J. Hinman, Jr. (Courtesy Chem. Abst.)*

A New Alloy of Aluminum, "Alpax". LEON GUILLET. Le genie civil, 82: 413-419, 441, 1923. An aluminum-silicon alloy containing about 13.5 per cent Si, patented by Pacz, an American metallurgist. Dissolving Si in Al does not give satisfactory results. The Al is heated to about 1000°C . and then Si is added. When temp. is reduced to about 930°C ., alkali salts, notably fluorides, are added. Material is mixed and allowed to cool. Si-Al alloys have been known since 1856.—*Jack J. Hinman, Jr. (Courtesy Chem. Abst.)*

The Determination of Dissolved Air in Small Quantities of Water. H. G. BECKER AND W. E. ABBOTT. Chem. Ind., 42: 484-6T, 1923. Methods of Letts and Blake and of Winkler for determining dissolved oxygen are not applicable to quantities less than 50 cc. of water. Authors have devised special apparatus and method for small quantities, based upon liberation of air from water when a solid is dissolved. Solid KOH is put in the apparatus, and 20-30 cc. of water drawn in: evolved gas is measured in graduated tube of small bore, passed through pyrogallol, and again measured. A cheaper substitute for the expensive KOH was sought and finally found, in air-free pellets of $(\text{NH}_4)_2\text{SO}_4$. (Cf. this JOURNAL, 11: 2, 508).—*Jack J. Hinman, Jr. (Courtesy Chem. Abst.)*

The Corrosion of Aluminum Cooking Utensils. C. KENNETH TINKLER AND HELEN MASTERS. *Analyst*, 49: 30, 1924. Stains on vessels in which tap water is boiled are due to solution of small amount of Al, leaving behind Fe and other impurities which show black and are not soluble in alkaline water. Stain may be removed by acid. On dissolving Al ware in NaOH, of a residual 2.2 per cent of black powder, all but 0.38 per cent was soluble in HCl.—*Jack J. Hinman, Jr. (Courtesy Chem. Abst.)*

Determination of Silica in Waters. F. DIENERT AND F. WANDENBULCKE. *Comptes rendus de l'Academie des Sciences*, 176: 1478-80, 1923. Waters from same geological formation, even though Ca content may vary, nevertheless possess similar amounts of Si. Sands of Seine allow solution of 3 p.p.m. SiO_2 , while those of Loire allow up to 12-14 p.p.m. Gravimetric method is long and inaccurate. Method proposed is based on yellow color formed with molybdate, and determines only the dissolved SiO_2 , not the colloidal material. The silicomolybdate only forms with ordinary molybdate reagent on heating; but with Meillere's reagent, $(\text{NH}_4)_2\text{MoO}_4$, H_2SO_4 and HNO_3 , in cold. More rapid results are obtained with molybdate and H_2SO_4 alone. *Procedure:* Take 50 cc. of water, add 2 cc. 10 per cent $(\text{NH}_4)_2\text{MoO}_4$ and 4 drops 1:4 H_2SO_4 . Compare with standards made similarly with Na_2SiO_3 , or with picric acid, of which a solution containing 36.9 mgm. per liter corresponds with a solution containing 50 p.p.m. SiO_2 . Maximum amount of SiO_2 for 2 cc. of 10 per cent $(\text{NH}_4)_2\text{MoO}_4$ is 60 p.p.m. Colloidal state of silica may be destroyed by heating on water bath with 0.2 grams NaHCO_3 for each 50 cc. of water. Since this solution attacks glass or the glaze of porcelain, the heating should be done in Pt dishes. Acidify with 2.4 cc. N/1 H_2SO_4 and treat as above after cooling. Water contains less dissolved SiO_2 after filtration.—*Jack J. Hinman, Jr. (Courtesy Chem. Abst.)*

The Campaign against Corrosion of Boiler Plates by Removing Gases from Water. HENRI MARCHAND. *Le Genie Civil*, 82: 423-5, 1923. The amount of O dissolved in water varies with origin, temperature, exposure to air, agitation, etc. Temperature is very important; the solubility varying from about 10 cc. per liter at 0° , to zero at 100° , being about 1 cc. at 90° . Harmfulness of water depends chiefly on temperature, as gas becomes more active as temperature rises. Below 60° , 1 cc. of O per liter is allowable; but at $75-80^\circ$, not over 0.5 cc. At 150° , active corrosion results if O present exceeds 0.2 cc. De-activation is most important for high temperatures. Processes of deactivation are: (1) Chemical. Water is passed through apparatus containing oxidizable metal, at as high a temperature as possible, and then filtered to remove $\text{Fe}(\text{OH})_3$. If previously rendered slightly alkaline, by passing through granular MgO , better results are obtained. (2) Mechanical. Agitation under diminished pressure removed about 80 per cent of O. Heating to $90-95^\circ$, even at ordinary pressures, reduces the O to 0.4 cc. per liter. In some installations, water is first heated to remove O and then put through chemical de-activator.—*Jack J. Hinman, Jr. (Courtesy Chem. Abst.)*

Mechanical Filtration (Elimination of iron from water). W. H. MAXWELL. *Water and Water Eng.*, 25: 401-3, 1923. Description of iron-removal plant at Waltham Abbey, with 12 Candy filters and 2 mgd. capacity. Deep chalk well supply contains iron in amounts varying from 0.65 up to 35 p.p.m. Filters contain 6 inch layer of "polarite", purpose of which is to occlude air for oxidation of the Fe. Plant removes 99.5 per cent of Fe.—*Jack J. Hinman, Jr. (Courtesy Chem. Abst.)*

Boiler Feed Water Circuits. JAMES WEIR. *Water and Water Eng.*, 25: 1923. Impurities may get into boiler feed water:—(a) by leakage into condenser system; (b) with the make-up water; (c) in feed water reservoir, by absorption of gases and air. Two methods are used to avoid the last difficulty: (1) the closed system, from which air is excluded; and (2), the deaeration system, in which the feed water is heated to drive off dissolved air. The closed system is not as successful as anticipated. Elastic air cushion in feed tank is absent, and constant level is not maintained. A common practice is to "seal" the tank by means of a small amount of escaping steam, which condenses very rapidly. The reservoir is virtually no more than an enlargement in the feed pipe.—*Jack J. Hinman, Jr. (Courtesy Chem. Abst.)*

Feed Water Problems. ANON. *Water and Water Eng.*, 25: 408-410, 1923. Few lime-soda plants soften below 80 p.p.m., and few filters take out more than 80 per cent of the deposit. Soda makes part of the chalk colloidal and filters are ineffective against this. Heat economizers or boilers change the colloidal matter to ordinary scale. "Algor" is a proprietary colloidal substance, used for treatment of boiler feed water. Feed water should have pH of over 9 (pure water has pH of 7).—*Jack J. Hinman, Jr. (Courtesy Chem. Abst.)*

The Utilization of Springs. DIENERT. *Rev. Hyg.*, 45: 1128-1148, 1923. A summary of practice, bringing up to date report made in 1911. Contains concise statement of properties required in a good potable water. Discusses sanitary surveys and interpretation of results. *Jack J. Hinman, Jr. (Courtesy Chem. Abst.)*

Determination of the Sulfate Ion by Precipitation as Barium Sulfate. K. P. CHATERJEE. *Z. anorg. allgem. Chem.*, 121: 128-34, 1922. From *Chem. Abst.*, 16: 2821, September 10, 1922. In precipitating sulfate with barium chloride, excess hydrochloric acid, up to a certain limit, causes more positive error due to absorbed chloride than excess barium chloride by itself. Solution should not contain more than 0.1 per cent hydrochloric acid by volume.—*R. E. Thompson.*

Some Geological and Biological Effects of Sulfate-Bearing Solutions on Humus Waters. A. G. HÖGBOM. *Bull. Geol. Inst. Univ. Upsala*, 18: 239-61, 1922. From *Chem. Abst.*, 16: 2830, September 10, 1922. After dry summer of 1914, many Swedish lakes sank very low, exposing post-glacial soil rich in sulphides, which were oxidized to efflorescent sulphates. When lakes rose again, sulphates were dissolved, and caused precipitation of humus compounds, affecting plants and fish.—*R. E. Thompson.*

Action of Salt Solutions on Mild Steel. J. A. JONES. Chem. Trade J., 70: 323-5, 1922. From Chem. Abst., 16: 2836, September 10, 1922. One of chief factors in production of cracks is presence of either internal or applied stresses which must exceed certain definite values. From experiments with salt solutions, it was concluded that solutions of nitrates yielded a product having such action on intercrystalline material that intercrystalline cohesion is reduced.—*R. E. Thompson.*

Some Causes of Rejections in Boiler Tubes. H. C. CARTER. Chem. Met. Eng., 26: 1113, 1922. From Chem. Abst., 16: 2836, September 10, 1922. Chief causes of rejections are: crookedness, non-uniformity of wall thickness, seams, tears, excessive scale, and brittleness, as shown by expanding, flattening, or hydraulic pressure tests. These defects are discussed.—*R. E. Thompson.*

Study and Report on Pitting and Corrosion of Boiler Tubes and Sheets. Character of Metal, Methods of Manufacture, Construction of Boilers, and Quality of Water Considered. ANON. Committee Report, Am. Railway Eng. Assoc. Bull., 243: 493, 1921. Railway Age, 72: 689, 1922. From Chem. Abst., 16: 2836, September 10, 1922.—*R. E. Thompson.*

Mechanical Lubricators. A. B. SMITH. Diesel Engine Users' Assoc., February 10, 1922. From Chem. Abst., 16: 2943, September 10, 1922. Numerous diagrams of lubricators given: deficiencies and advantages discussed. Most difficult task of lubricator is to deliver oil in small quantities against high pressure.—*R. E. Thompson.*

Chlorination of Municipal Water Supplies. JOS. RACE. J. State Med., 30: 263-6, 1922. From Chem. Abst., 16: 2945, September 10, 1922. History of development of chlorination given. "Aftergrowths" develop as secondary cycle with bleach and liquid chlorine. At Denver, Colo., "aftergrowths" entirely disappeared when chloramine was substituted.—*R. E. Thompson.*

Rain Water. P. DE SORNAY. Rev. agr. Maurice, 1: 78, 1922. From Chem. Abst., 16: 2945, September 10, 1922. In Mauritius, rain contains 2.14-4.11 mg. SO₃, 3-4.57 mg. chlorine, and 1.45-1.70 mg. nitrogen per liter.—*R. E. Thompson.*

Correlation of Stream Pollution Criteria from Studies on Naugatuck and Hocanum Rivers in Conn. J. F. JACKSON. Am. J. Pub. Health, 12: 124-33, 1922; Pub. Health Eng. Abst., April 15, 1922. From Chem. Abst., 16: 2945, September 10, 1922. Chemical and bacteriological analyses did not show definite correlation between appearance and actual condition of water, owing to varying character and form of suspended solids. Acids and calcium salts affected bacterial content. Owing to inhibitory effects of wastes, dissolved oxygen and dissolved oxygen demand tests could not be used as indices of pollution. The dilution factor is discussed.—*R. E. Thompson.*

Behavior of Concrete in Solutions of Ammonium Salts. R. GRÜN. Zement, 10: 425-6, 1921. From Chem. Abst., 16: 2974, September 10, 1922. Concrete should be protected from ammonium salts, which have detrimental action similar to that of acids, acid radicals in salts combining with lime, forming soluble salts, and liberating ammonia.—*R. E. Thompson.*

Tests on Absorptive Qualities of Cement Blocks. STANTON WALKER. Eng. News-Rec., 88: 282-4, 1922. From Chem. Abst., 16: 2974, September 10, 1922. Absorption varies inversely with strength; increased by using more water with mix; decreased by using coarser aggregates, increasing quantity of cement, or storing specimens in moist place immediately after molding. With quantity constant, absorption decreases as density increases. By varying quantity and with other factors constant, absorption decreases as density decreases.—*R. E. Thompson.*

The Determination of Tar Acids and Tar Bases in Road Drainage and Mud. J. J. FOX AND A. J. H. GAUGE. J. Soc. Chem. Ind., 41: 173T, 1922; cf. C. A. 14: 3041. From Chem. Abst., 16: 2974, September 10, 1922. Solutions of small quantities of tar acids or bases, if in non-sterile water, should be analyzed as soon as possible to avoid loss by biological change; in one case amount of tar acids present diminished in 2 days to 25 per cent of original value.—*R. E. Thompson.*

Resistance of Cement Mortars to Abrasion. H. NITZCHE. Zement 11: 65-6, 79-81, 99-102, 1922. From Chem. Abst., 16: 2975, September 10, 1922. Blast furnace slag cements behaved best, while iron portland cements were least resistant. Hydraulic modulus appeared important but there was no apparent connection between kind of sand used and resistance to abrasion.—*R. E. Thompson.*

The Significance of Fuel Losses Through Incomplete Combustion of Low-Grade Coals. F. EBEL. Glückauf, 58: 739-44, 1922. From Chem. Abst., 16: 2977, September 10, 1922. Most important loss is combustible material remaining in ash. Flue losses and losses through formation of carbon monoxide are of secondary importance.—*R. E. Thompson.*

Some Characteristics of Petroleum Oils Used in Diesel Engines. H. MOORE. Diesel Engine Users' Assoc., April 7, 1922. From Chem. Abst., 16: 2984, September 10, 1922. Extensive discussion. Eight tests of fuel oils are suggested as being of greatest importance: specific gravity, closed flash point, cold test, heat value, ash content, water content, coke value, and content of hard asphaltum. Design of engines greatly affects their capability of burning heavy oils, 4 predominating factors being speed of engine, compression pressure, maximum mean effective pressure at which engine will run, and type of injection (blast air or mechanical).—*R. E. Thompson.*

Water in Relation to Dyeing. JOHN MACGREGOR. Color Trade J., 9: 43-8, 1921. From Chem. Abst., 16: 2998, September 10, 1922. Discussion of

difficulties which may occur when impure water is used with various classes of dyestuffs.—*R. E. Thompson.*

The Purification of Water Used in Washing Coal. K. IMHOFF. Glückauf, 58: 776-8, 1922. From Chem. Abst., 16: 2977, September 10, 1922. Present methods of purifying water after coal washing, with subsequent recovery of coal sludge, discussed. Most economical processes are based on sedimentation.—*R. E. Thompson.*

Surface Tension Phenomena and Electrostatics. R. H. JARVIS AND D. W. LEEKE. Eng. Mining J. Press., 114: 17-8, 1922. From Chem. Abst. 16: 3244, October 10, 1922. Particles on liquid surface which are wetted attract each other, but are repelled by dry particles. Particles which are wetted by water are attracted by positively charged hard rubber rod, while particles not wetted are repelled.—*R. E. Thompson.*

Entrainments by Precipitates. P. DUTOIT AND ED. GROBET. J. Chim. Phys., 19: 328-30, 1921. From Chem. Abst., 16: 3245, October 10, 1922. Clean separation of calcium and magnesium as oxalate, barium and calcium as sulfate, and barium and strontium as chromate, can be effected by vigorous mechanical stirring during addition of precipitant and by adding reagent dropwise at point of maximum agitation.—*R. E. Thompson.*

Intercrystalline Cracking of Mild Steel in Salt Solutions. J. A. JONES. Trans. Faraday Soc., 17: I, 102-9, 1921. From Chem. Abst., 16: 3292, October 10, 1922. Property of inducing rapid cracking in stressed mild steel has been observed in case of solutions of sodium, potassium calcium and ammonium nitrates. Similar action of solutions of caustic alkalies is well known.—*R. E. Thompson.*

Strength and Elasticity of Boiler Plates at Elevated Temperatures. H. J. FRENCH. Chem. Met. Eng., 26: 1207-9, 1922; cf. C. A., 16: 1384, 1927. From Chem. Abst., 16: 3299, October 10, 1922. Proportional limit is maintained or increased with first temperature rise, and tensile strength has slight maximum about 250°; but both fall off badly at higher temperatures. Reduction and elongation have minimum about 260° but recover original value around 450°.—*R. E. Thompson.*

Corrosion; with Special Reference to the Ferrous Metal and the Deteriorations of Ships. A. PICKWORTH. Electrician, 89: 100-1, 1922. From Chem. Abst., 16: 3299, October 10, 1922. General survey, and some of methods of retardation and prevention now employed.—*R. E. Thompson.*

Corrosion of Brasses and Bronzes by City Water Supply of Buenos Aires. A. A. BADO AND R. A. TRELLES. Anales asoc. quim. Argentina, 10: 16-9, 1922. From Chem. Abst., 16: 3300, October 10, 1922. The water contains no unusual constituents, and is slight alkaline owing to bicarbonates. Typical

brasses and bronzes containing only copper, tin, zinc, lead, and iron were suspended in the water for 702 days; loss in weight varied from 14 to 19 mgm. per sq. cm.—*R. E. Thompson.*

High Pressure Steam, up to Sixty Atmospheres, in Power and Heat Economy. O. H. HARTMANN. *Z. Ver. deut. Ing.*, 65: 663-71, 713-9, 747-53, 848-52, 998-93, 1047-8, 1921. From *Chem. Abst.*, 16: 3351, October 10, 1922. Summary of experiments made by Wilhelm Schmidt in 1911-14, and 1916-18.—*R. E. Thompson.*

Control of Causticizing Lime by Determining Active Lime Content. G. K. SPENCE. *Paper Industry*, 3: 1095-7, 1921. From *Chem. Abst.*, 16: 3365, October 10, 1922.—*R. E. Thompson.*

Preparation of an Aqueous Standard Soap Solution for Determining the Hardness of Water. ED. JUSTIN-MUELLER. *J. pharm. Chim.*, 26: 18-21, 1922. From *Chem. Abst.*, 16: 3354, October 10, 1922. Clark's soap solution, modified by Boutron and Boudet, is rendered more sensitive by being made 0.1 strength. Solution is simpler to prepare and avoids use of ethyl alcohol. Boil 3.5 g. Marseilles soap with 200 cc. water: when clear, add water to make 900 cc. and filter through cotton. Standardize with calcium chloride (0.25 g. in 1000 cc.) or barium nitrate (0.59 g. in 1000 cc.)—24 cc. soap solution = 40 cc. of calcium or barium solution, corresponding to 2.4 cc. = 22° Boutron and Boudet's solution. Using 40 cc. water, pure water requires 2 cc. to persistent foam: temporarily hard water, after boiling and filtering, retains precipitated calcium carbonate equivalent to additional 3 cc. soap solution. Hence no. cc.—2 = no.° total hardness, and no. cc. —5 = no.° permanent hardness.—*R. E. Thompson.*

Chemical Studies of Swimming Pool Water. ROY. W. GOSHORN. *Hahne-mannian Monthly*, 57: 460-9, 1922. From *Chem. Abst.*, 16: 3354, October 10, 1922. Chlorides, and nitrogen in all forms examined, were in greatest quantities in pool used exclusively by women, nitrogen as urea being 10 times as great. Chlorides, and nitrogen as free ammonia and as nitrates, were higher in pools without filtration. Filtration did not affect urea content. Copper sulfate treatment had no effect on chloride and nitrate content. Possible explanation of results, in fact that women wore bathing suits during preliminary shower and bathing period, while men did not.—*R. E. Thompson.*

Selection and Treatment of Waters for Spraying Purposes with Special Reference to Santa Clara Valley. E. R. DE ONG. *California Agr. Expt. Sta., Bull.*, 338: 301-14, 1921. From *Chem. Abst.*, 16: 3361, October 10, 1922. General discussion of water softening. Hard water forms dangerous combinations with, or destroys efficiency of, many forms of insecticides. Water containing 20 p.p.m. Cl reported as dangerous to use with acid arsenate of lead. Basic arsenate of lead should be used with hard or alkaline waters.—*R. E. Thompson.*

Alum and Its Analysis. JAMES SCOTT. Paper-Maker, Brit. Paper Trade J., 63: 629-30, 1922. From Chem. Abst., 16: 3366, October 10, 1922. Alum is tested for iron, insoluble matter, alumina content, and acidity. Best grades contains less than 0.00025 per cent iron; second quality less than 0.2 per cent; and third, used for colored papers and water purification, ranges above that amount.—*R. E. Thompson.*

Some Causes of Cracking and Disintegration of Portland Cement Concrete. R. E. STRADLING. Concrete and Constr. Eng., 17: 393-8, 475-80, 1922. From Chem. Abst., 16: 3373, October 10, 1922. Reasons for cracking and disintegration numerous, not well defined, and, in many cases, not understood. By far the greater number of failures due to faulty workmanship, or conditions to which work is exposed. Only few cases can be traced to poor material.—*R. E. Thompson.*

Disintegration of Cement Tile in Peat. F. J. ALWAY. J. Am. Peat. Soc., 15: 3, 15-25, 1922. From Chem. Abst., 16: 3374, October 10, 1922. Four main causes are: (1) Humic acids, which remove lime. These cause greater damage in swiftly moving water, since in quiet water, coating of insoluble calcium humate is formed and protects cement. (2) FeS_2 , either as pyrite or marcasite, which, on exposure to oxygen and moisture, oxidizes to ferrous sulfate and sulfuric acid, both of which remove lime. (3) Hydrogen sulfide, which reacts with lime cement to form calcium sulfide, then sulfhydrate and sulfate. (4) Alkali water, which contains sodium sulfate, magnesium sulfate, and magnesium chloride. These react with lime to form either soluble compounds, or those having larger molecular volumes.—*R. E. Thompson.*

Determination of the Hardness of Water for Technical Purposes. G. WEISSENBERG. Z. angew. Chem., 35: 177-179, 1922. Chem. Ind., 43: B 150, 22 February, 1924. Tables are given comparing hardness of a number of samples of water as determined by gravimetric analysis, by Winkler's potassium oleate method (Lunge-Berl Chem. techn. Untersuchungsmeth. 4 Aufl. 2, 234) by Blacher's potassium palmitate method (J. 1912, 555, 1913, 158), and by the modified soap method (Z. angew. Chem., 1913, 26, 140). Potassium oleate method gives reliable results only in case of water with low degree of hardness, and containing no excess of magnesium salts, such as purified water; results are affected only to slight extent by presence of free carbon dioxide. Results obtained by potassium palmitate method are reliable in presence of neutral salts, but are unreliable if free carbon dioxide present. Free carbon dioxide, however, can be removed by neutralizing with dilute hydrochloric acid, using methyl orange or methyl red as indicator, blowing air through solution and then making faintly alkaline by addition of 2 drops alcoholic sodium hydroxide solution. Solution is then titrated with potassium palmitate in presence of phenolphthalein. Potassium palmitate method gives reliable results with waters having moderate or high degree of hardness; if carbon dioxide removed, it can be used for natural and purified waters. Modified soap method gives the most accurate results and is the most suitable for rapid determination of hardness of all waters used for technical purposes (L. A. C.).—*A. M. Buswell.*

Removal of Iron from Drinking Water. KISSKALT. Gas-u. Wasserfach, 1924, 67: 3-4. Chem. Ind., 43: 12, B 23. March 21, 1924. A number of processes have been described in which iron is removed from water by aeration effected by allowing water to flow down towers packed with coke, or by spraying it through nozzles. In this way iron is oxidized to the hydroxide, which remains in colloidal solution until it is coagulated and removed by the action of the material forming the filter bed. Too much aeration is to be avoided if water contains a relatively large proportion of lime and carbon dioxide, else latter may be driven off, leaving insufficient to hold the lime in solution as bicarbonate, with result that calcium carbonate is precipitated and blocks the pipes. (Cf. C I., 1923, 343 A.).—A. M. Buswell.

Titration of Hydroxyl and Carbonate Ions in the Presence of One Another in Drinking Water. K. SCHERINGA. Pharm. Weekblad, 61: 113-115, 1924. Chem. Ind., 43: 12, B231, March 21, 1924. The titration and calculation by the standard method, namely two separate titrations, using phenolphthalein and methyl orange respectively as indicators, may be simplified, when water is alkaline to phenolphthalein, by titrating first with latter and then with methyl orange as indicator in same solution. If amounts of acid used in each case are the same, only CO_3^{2-} ions are present; if more is required with methyl orange, HCO_3^- ions, but no OH^- ions are present; if less is required, OH^- is present. The calculation is carried out by simple arithmetic.—A. M. Buswell.

Creamery Waste Purification by Means of Activated Sludge. M. LEVINE. Eng. News-Rec., 92: 152, 1924. Chem. Ind., 43: 12, B231, March 21, 1924. Experiments on small scale at Iowa State College, Ames, Iowa, have shown that creamery wastes can be satisfactorily purified by activated sludge process. Using 2 per cent skim milk, an activated sludge was prepared in 2 weeks, and marked reductions in turbidity, acidity, total solids, organic nitrogen, and particularly in oxygen consumed and demand, were obtained with an aeration period of 16-25 hrs. when employing 20 per cent of sludge and 50-60 cub. ft. of air per gal. The reduction in oxygen requirement was generally 95-98 per cent. With partially activated sludge, aeration periods of 6 hrs., and 15.6 cubic feet of air per gal., an average reduction of 43.9 per cent of solids, 77.7 per cent of organic nitrogen, and 76 per cent of oxygen consumed and demand was obtained. A further reduction of 20 per cent, together with a reduction in air requirements to 11.4 cub. ft. per gal., was obtained by extending aeration period to 12 hours. Buttermilk was more readily purified than skim milk. With better distribution of air, improved results are anticipated; elimination of 95 per cent of the oxygen-requiring constituents from 2 per cent skim milk or buttermilk was not sufficient to yield stable effluents. Aeration of 2-3 per cent skim milk with activated sludge for 4 hrs. was found sufficient to produce effluents which would not become appreciably acid under anaerobic conditions, and probably suitable therefore, for admixture with sewage in septic tanks.—A. M. Buswell.

Process of Treating Sewage Sludge. MACLACHLAN REDUCTION PROCESS Co., Inc., Assess. of A. MacLachlan. E. P. 196, 239, 12.7.22. Conv., 12.4.22. Chem. Ind., 43: 12, B231, March 21, 1924. Activated sludge is treated with sulphur dioxide gas alone, or with a mixture of sulphur dioxide and steam, until gelatinous solid constituents are completely granulated. Sludge is then allowed to settle, supernatant water removed by decantation, and residue passed to filter-beds, filter-presses, or the like, to be further dewatered. Treatment with sulphur dioxide in manner described facilitates considerably dewatering and drying of the sludge, retards putrefaction, and conserves nitrogen. Final product may contain 75 per cent more nitrogen than product from untreated sludge, and 40 per cent more than that from sludge treated with acids—A. M. Buswell.

Effects of Storage on Artificially Polluted Waters. R. C. FREDERICK. Analyst, 49: 63-73, 1924. Chem. Ind., 43: 14, B-274, April 4, 1924. Bulk quantities, distilled from all-glass apparatus and free from ammonia, were treated with fresh suspension of soil taken from underneath growing turf in order to reproduce character of natural water, and were polluted with 1 part in 22,000 of urine, of feces, and of mixture of equal parts of urine and feces. The quantities were then divided into samples of exactly similar original composition, which were filled into stoppered bottles, which were set aside under predetermined conditions and their contents analyzed after various periods of storage, up to 100 days, for free ammonia, albuminoid ammonia, nitrites, and nitrates. In samples stored in dark at ordinary temperature, the chemical changes took place comparatively slowly, and quite different results were obtained according to whether the pollution was urinary, fecal, or a mixture of both. The analytical results, which are given in a table, completely disprove the view that the chemical evidence of excretal pollution in water disappears rapidly on storage, and show that, if pollution of the supply has only been very recent, the evidence in samples would be more pronounced if the analysis were actually delayed for a considerable period. The quantity of albuminoid ammonia found was at no time a small fraction of that of the free ammonia; it was seldom appreciably less and was frequently larger than the quantity of free ammonia. A statistical consideration of the analyses of nearly 1000 samples of every kind of water supply showed that, of waters considered potable, none contained free ammonia in excess of 0.003, albuminoid ammonia in excess of 0.008, or nitrites in excess of 0.0001 pt. per 100,000 after excluding samples which could have derived these substances from other than excretal sources.—A. M. Buswell.

Formation of Methane from Sewage Sludge. BACH AND SIERP. Zentr. Baktr. u. Parasitenk., II Abt., 60: 318-328, 1923. Chem. Zentr. 95: I, 369-370, 1924; Chem. Ind., 43: 14, B-275, April 4, 1924. Decomposed sludge from septic tanks contains methane bacteria, and considerable quantities of gas containing methane, carbon dioxide, and nitrogen may be obtained from it. It can also be used to ferment calcium acetate, whereby calcium carbonate, methane, and carbon monoxide are obtained. Hydrogen is never obtained by the further decomposition of the sludge; its occurrence must be ascribed to

presence of more recent sludge. By repeated decantation of decomposed sludge, mixed with nutrient inorganic material and with calcium acetate solution, a preparation is obtained which sets up methane fermentation more quickly and energetically than untreated sludge. Presence of nitrogen in gas from sludge fermented in presence of calcium acetate is due to breakdown of organic nitrogen compounds and not to denitrification of nitrites, and the undiminished nitrogen content in gas from sludge which has been repeatedly fermented must be ascribed to decomposition of dead bacteria. Presence of nitrites may inhibit, partially or completely, methane fermentation. Concentration of bacteria has marked influence on rate of fermentation, and a certain minimum of decomposed sludge is necessary for its continuance.—A. M. Buswell.

Electro-Osmotic Process for the Partial or Complete Purification of Water. ELEKTRO-OSMOSE A. G. (Graf Schwerin Ges.). G. P. 383, 666, 11.9.21. Chem. Ind., 43: 14, B-275, April 4, 1924. Water to be freed partially or completely from salts is submitted to action of an electric current between diaphragms arranged so that diaphragms nearest positive and negative poles become respectively positively and negatively charged. Preferably, water is sprayed in thin sheet into middle chamber of a three compartment apparatus, and is therein submitted to action of current as described. The spray is preferably directed in direction of migration of substances to be removed. Water can, in this manner, be purified to any degree for electrolysis, and completely freed from living organisms.—A. M. Buswell.

The New Rapid Sand Filtration Plant at Cambridge, Mass. GEO. A. JOHNSON. Amer. City, 30: 241-246, 1924. (From paper before N. Eng. W. W. A.) Filtration works of 14 mgd. nominal capacity were put in full operation on April 25, 1923. Supply is from two impounding reservoirs, Hobbs Brook, of 2,500 mg., and Stony Brook, of 400 mg. capacity; latter being fed along natural drainage channel from former. Aqueduct consisting of 1.42 miles of 30-inch C. I. pipe, 0.91 mile of 36-inch pipe, 5.2 miles of 63-inch concrete conduit and 0.36 mile of C. I. pipe brings the water by gravity from lower, or Stony Brook, reservoir to filtration plant. Excess water is by-passed over weir into Fresh Pond, holding 400 mg., which is used only as reserve for high peaks, and necessitates pumping. Drainage area above diversion point is 23.57 sq. mi., with resident population of 120 per sq. mi. Hardness of raw water ranges from 20 to 40, with average about 30 ppm.; color ranges 20 to 50, with average about 25. Turbidities are low. Purification plant consists of covered coagulating basin, 10 rapid sand filters, filtered water aerator, clear water basin, sterilizing equipment, wash water receiving basin, and low-lift pump. Coagulating 137 x 96 x 16 ft. deep, has retention of 2.5 hours at full capacity, and is divided by longitudinal wall into two compartments. Ten filter units of concrete construction are arranged in single row. Each filter has 480 sq. ft. sand area, equivalent to 1.4 mgd. Filters have Wheeler bottoms, 9 inches graded gravel, and 27 inches sand. Filtered water is aerated; dosed with chlorine; then flows to covered clear basin of 4.0 mg. capacity; thence to high service pumps. Special features are, (a) arrangement for retaining filter wash water

and returning to coagulating basin, in order to conserve wash water and accelerate coagulation; and (b) device for aerating filtered water, consisting of sloping concrete slabs with imbedded herringbone baffles. Sulfate of alumina, applied as solution, is the coagulant. Soda-ash is used to compensate for deficient alkalinity during freshet stages. Itemized cost of improvements is given, amounting to total of about \$768,000 of which \$607,000 was properly chargeable to filter plant.—*W. Donaldson.*

The Public Works of the New Model Town, Mariemont, Ohio. R. W. HORNE. *Amer. City*, 30: 247-250, 1924. New suburb of Cincinnati is being provided with water supply, sewers, storm drains, and paving. Water supply is taken from Cincinnati mains. Local system consists of 14 miles of supply and distribution mains, 6 to 12-inch C. I., and 3 miles of $\frac{3}{4}$ -inch brass service pipe, latter being selected because of stated corrosive action of local water. Cost of water system complete was \$209,000.—*W. Donaldson.*

The Water Works of Greenville, Miss., Put on a Paying Basis. E. M. FOSTER. *Amer. City*, 30: 267-270, 1924. Methods are described by which yearly operating expenses of a municipally owned water works, supplying population of 11,000, were reduced from \$52,000 to \$20,000. By leak inspections, metering 45 per cent of consumers, and reducing pressures from 60 to 40 lbs., consumption was reduced from 3.0 mgd. to 1.6 mgd. with further probable decrease by metering to 1.0 mgd. Former supply system involved pumping well by air-lift into reservoir from which water was repumped directly to distribution, air compressors and centrifugal pumps being electrically-driven but with steam reserve. This has been supplemented by two new Layne & Bowler wells, equipped with motor-driven vertical shaft pumps delivering direct to distribution against 40 lbs. pressure. Wells are 525 ft. deep upper 82 feet being 24-inch, to accommodate pump which is set 80 feet below surface, while lower casing is 10-inch. Wells have wire wound screen. Automatic regulating valve on pump discharge maintains 40 lbs. pressure on mains, pump pressure being 20 to 60 lbs. higher. Comparative six day tests showed air-lift to require 1.86, and Layne system 1.10 K.W.H. per 1,000 gallons, pumped; which, at $2\frac{1}{2}$ cents, equals saving of \$7,250 per annum.—*W. Donaldson.*

Improvements in the Water Supply of Ogden City, Utah. B. B. BREWSTER. *Amer. City*, 30: 279-281, 1924. Supply is from 34 flowing artesian wells, 4-inch and 6-inch casings, and 120 to 200 ft. deep. Inadequacy of artesian supply to meet growing demand has been met by equipping all wells with air-lift in 1922-23: equipment comprising five single stage compressors, each with 50 H.P. motor drive, also booster pump, for supplying water for cooling and lawn sprinkling. Air-lift has augmented the well deliveries and decreased the draw-down by 3 ft. since pumping operation started.—*W. Donaldson.*

Unique Method of Repairing Large Water Mains. ANON. *Amer. City*, 30: 281, 1924. A cracked 48-inch water main in Baltimore was welded in place by portable electrical equipment mounted on truck, at cost of \$305, as against estimated cost of \$1,040 by usual replacement methods. Only necessary to expose and drain main below crack.—*W. Donaldson.*

Water Meters in Chicago. ANON. *Amer. City*, 30: 297, 1924. According to 47th An. Rep. of Dept. of Pub. Wks. for year 1922, 1471 additional meters were set, bringing total to 32,034. Average maintenance cost was \$4.18.—*W. Donaldson.*

How Should Water Taste. JOHN R. BAYLIS. *Amer. City*, 30: 365-368, 1924. (Paper before Amer. Soc. for Municipal Improvements.) Plea for more attention to good tasting quality of public water supplies. Palatability of Baltimore supply has been improved by increase in capacity of impounding reservoir, decrease of chlorine dose, better purification efficiency, and control of micro-organisms. Properties of water affecting taste, such as mineral salts, iron, organic content, micro-organisms, corrosion, chlorination, and trade wastes, are discussed, together with remedies available. Pure palatable water can be supplied at reasonable cost if public insists.—*W. Donaldson.*

Water Meters in Philadelphia. ANON. *Amer. City*, 30: 372, 1924. Annual Report for 1923 shows 11, 881 meters placed during that year, bringing total to 114,000, as against 281,000 unmetered services, thus making a 29 per cent metered city. Practically half of the \$5,833,000 water rent receipts are from metered services. Meters are owned by householders, and repaired by Bureau at owner's expense.—*W. Donaldson.*

How Should Hydrant Rentals be Charged in a Municipal Plant? W. C. BROCKWAY. *Amer. City*, 30: 397-8, 1924. Compensation for fire protection services out of general tax fund, through hydrant rental charge, is more equitable than having cost absorbed in charges for general water consumption; though hydrant rentals usually do not cover entire cost of fire protection services.—*W. Donaldson.*

Planning a Water Works System. ANON. *Amer. City*, 30: 409-12, 1924. Excerpts from pamphlet by Cast Iron Pipe Publicity Bureau call attention to value of good water works system and give sound advice as to procedures, to towns contemplating public supply works, covering engineering services, selection of sources, water requirements, pumping, duplication of equipment, storage capacity, distribution system, pipe laying, metering, fire hydrants, records, and choice of officials.—*W. Donaldson.*

Warning.—Spring Floods May Contaminate Water Supplies. *Amer. City*, 30: 443, 1924. Bulletin of New York State Dept. of Health warns of special danger to water supplies incident to spring run-off, and urges that special precaution be taken to meet such overload conditions.—*W. Donaldson.*

The Removal of Iron From the Public Water Supply of Shelby, Ohio. PHILIP BURGESS. *Amer. City*, 30: 468-70, 1924. Private Water Company at Shelby, though treating an iron-bearing well water with fairly satisfactory results since 1905, has installed new plant of modern design and more adequate capacity of nominally 1.0 mgd., comprising two new dug wells, 45 ft. deep, which replace former drilled wells, a pumping station, and iron removal plant.

Motor-driven centrifugal pumps deliver water to purification plant, where it is distributed by perforated pipe over aerating device, consisting of three superimposed trays located over one end of settling basin. Trays are 4.5 x 9 ft. in plan, giving effective area of 40.5 sq. ft.; are each 12 inches deep, and are spaced 12 inches apart. Wire screen, $3\frac{1}{2}$ inch mesh, forms bottom of each tray and supports coke layer, $\frac{1}{2}$ to 3 inch size. Aërated water drops into settling basin of one hour's nominal retention; thence passes to two gravity filters of 240 sq. ft. sand area each, designed for rate of 100 mgd. Filters have cast-iron manifolds with $1\frac{1}{4}$ -inch perforated C. I. laterals. Filter bed consists of 12-inch gravel layer $\frac{1}{2}$ to 2 inch, and 24 inches sand of effective size 0.49 mm. Filters are washed by standpipe pressure, at rate 20 to 24 inches vertical rise per minute. Filtered water storage of 0.25 mg. is provided underneath filters. Raw water contains 6 to 16 p.p.m. iron, 40 to 50 p.p.m. CO_2 , and no dissolved oxygen: aërated water contains 20-30 p.p.m. CO_2 and 65 per cent oxygen saturation; filtered water contains 10 to 15 p.p.m. CO_2 , and 0 to 0.3 p.p.m. dissolved iron. Author draws following conclusions from operation experience; (a) Aëerator has important function, and must be cleaned at intervals to avoid clogging with iron, which results in loading filters and poor efficiency (b) Settling basin is useful in removing substantial amount of iron as sludge. (c) A loading of 10 gals. per sq. ft. per minute on coke aëerator would be better than 17 gals., for which it was designed. (d) Deeper gravel layers than 12 inches, in filters, are desirable, to obviate gravel shifting. Improved quality of water supply has pleased consumers, gained a rate increase for the company and well justified the plant cost of \$35,000.—*W. Donaldson.*

Improvements in the Water Works Power Plant, Dubuque, Iowa. L. J. JELLISON. *Amer. City*, 30: 470, 1924. With a voted bond issue of \$325,000 for water works improvements, Dubuque is building new fireproof pumping station, of brick and concrete construction, with steel roof truss covered with tile, window frames and sashes of steel, and concrete floor. New equipment includes boilers, pumps, and motor-driven air compressors, for increasing output of artesian wells from 1 to 5 mgd.—*W. Donaldson.*

Copper Sulfate Treatment of a New England Water Supply. E. SHERMAN CHASE. *Amer. City*, 30: 488-493, 1924. (From paper before New England Water Works Assn.) Description of unfiltered water supply at Rockport, Mass., 30 miles northeast of Boston, and remedial treatment used. Supply is from Cape Pond, a natural body of water about 3,200 ft. long, 600 ft. average width, maximum depth of 23 ft., having total capacity of 182 mg., of which 85 mg. is available. Watershed comprises 222 acres, mostly forested. Intake pipe taps deepest part of pond. Complaints relate principally to odors and tastes from microscopic organisms, though corrosion and red water troubles exist. Predominant organisms are *Asterionella*, *Tabellaria*, *Anabaena*, and *Dinobryon*. Tastes and odors were substantially controlled by applications of copper sulfate May 22, May 27 and Nov. 3, 1922, and Aug. 14, 1923, the doses being $2\frac{1}{2}$, 5, $4\frac{1}{2}$, and 6 lbs. per million gals., respectively. Dosing was done by towing sack behind rowboat. White perch were killed by second treatment

and shallow-water minnows by fourth treatment. Full effect of copper treatment not reached until many days after dosing. Flushing of watermains after copper treatment caused improvement in water delivered to consumers.—*W. Donaldson.*

The Application of Aërial Surveying to Water Supply Problems. C. G. DRUEGER. *Amer. City*, 30: 493-4, 1924. Surveys by aërial photography have advantages over other methods, for preliminary work on water supply. They are more accurate, require less time and money, and have greater legal value in settling damage claims.—*W. Donaldson.*

Goiter Survey by Michigan Department of Health (Preliminary Report). Supplement to Michigan Public Health 12: 1, January, 1924. Bureau of Laboratories has conducted studies of the drinking waters in Michigan with reference to iodine content. Medical examinations of school children have been started. In county of Wexford rural prevalence of goiter in school children was 12 per cent higher than in city of Cadillac: rural water supplies contain no iodine; that of city, a very slight trace.—*E. S. Chase.*

Endemic Goiter as a Public Health Problem. O. P. KIMBALL, M.D. Michigan Public Health, 12: 2, 59, February, 1924. Account of the disease and of preventive measures against it. Refers to treatment of water supply; but author prefers, on ground of economy, individual methods of prevention by feeding iodostearine chocolate tablets to supply iodine deficiency.—*E. S. Chase.*

Hard Water and Water Softening. E. F. BADGER. Michigan Public Health, 12: 3, 113, March, 1924. A general and popular article dealing with hard water, its effects, cost to public, origin of hardness, water softening, and its cost.—*E. S. Chase.*

Health Bulletin, State of Connecticut. 38: 2, 27, February, 1924. Typhoid fever death rate in Connecticut in 1923 was 2.6 per 100,000 population, compared with 3.0 in 1922.—*E. S. Chase.*

Report on the Public Water Supply of Delaware, Ohio. F. H. WARING. Public Health Reprint No. 776. Consisted of ground water, supplemented by use of Olentangy River, supplemental supply being used fairly regularly during 1920 and 1921. Disinfection of the river water failed to give uniformly satisfactory results. Outbreak of enteritis occurred in October and November, 1921. Typhoid death rate in Delaware averaged 32.1 per 100,000 for nine years prior to chlorination and 11.3 thereafter. Filtration of the supply was recommended.—*E. S. Chase.*

Will Combat Menace of Cross Connections. ANON. Weekly Bulletin California State Board of Health, 8: 15, 57, May 14, 1924. Regulations passed requiring permit of State Board of Health for cross connections. Water companies of municipalities are to be responsible to consumers for pollution of public supply through cross connections.—*E. S. Chase.*

Typhoid Caused by Breaks in Water and Sewer Lines. ANON. Weekly Bulletin California State Board of Health, 8: 15, 59, May 24, 1924. From April 27 to 30, 1924, reports of more than 200 cases of severe vomiting and diarrhea were received from that portion of South Pasadena supplied with water from two wells near a pumping station in Pasadena. Investigation revealed stoppage or back flow in main outfall sewer in vicinity of pumping station. Samples of water showed gross pollution. Pumping plant was shut down and water in reservoir chlorinated. Further investigations showed that low pressure steel pipe from two wells to pumping station passed directly over lateral sewer in street and that near this crossing the steel pipe was badly corroded with sewer gas, containing about a dozen holes $\frac{1}{4}$ in. in diameter. Sewer was found to be cracked, and, with surcharged sewer and corroded water pipe, opportunity for pollution of supply was ample. Two cases of paratyphoid and 17 cases of typhoid were reported in South Pasadena up to May 19.—*E. S. Chase.*

The Drought of 1923. ANON. Health Bulletin of the State of Conn. 38: 3, 67, March, 1924. Comparison of rainfall in 1923 at certain Conn. cities with previous records. Drought was felt mainly in localities close to sea. Drier periods, however, have been experienced in the past.—*E. S. Chase.*

Swamp Drainage. E. H. LOTZ. Health Bulletin State of Conn., 38: 5, 129, May, 1924. Water collected in one of the reservoirs of Southington, Conn., water works was high in color, due to 15 acre swamp tributary to reservoir. A ditch was excavated completely around the swamp. The results obtained were satisfactory, as color was nearly eliminated and runoff was increased. Part of ditch was dug by hand, at cost of 35¢ per foot; but larger portion was excavated by blasting and cleared by hand, at total cost of about 21¢ per foot.—*E. S. Chase.*

Semi-Annual Report Division of Sanitary Engineering. Illinois State Department of Health. HARRY F. FERGUSON. Illinois Health News, 10: 3, 101, March, 1924. An outline of activities of Division during last six months of 1923. Refers to epidemic in Chicago during November as the first of water-borne typhoid fever in the State since that at the Chicago and Alton shops, Bloomington, in 1919. Epidemic at Chicago comprised a little less than 200 cases and 16 deaths. It was confined to an area with population of 450,000, supplied from 68th Street pumping station. At time of infection, lake water carried more than average pollution due to reversal of flow in sewage laden Calumet River and out flow of some sewage at 39th Street pumping station of the Sanitary District. Health Department recommended employment of sanitary engineer to give entire time to sanitary control of water supply.—*E. S. Chase.*

A Unique Method of Cleaning Filter Sand. C. H. CAPEN. N. J. Public Health News, 9: 6, 190, May, 1924. Rapid sand filters at Salem, N. J., became badly clogged with accumulations of fine mud. Ordinary washing failed to clean filters and chemical treatment was resorted to. One hundred seventy-five pounds of caustic soda and 250-300 pounds of soda ash were applied in solution to each filter (190 sq. ft.) from the top and heated to about 175°F. by

steam. This temperature was maintained in the filter bed for 40 hours in one case, and 80 hours in another. The filters were then washed several times. Stratified mud layers accumulated on sand surface and were removed by hand. Marked improvement in condition of filters was effected.—*E. S. Chase.*

Typhoid Epidemic in Ramsay, Michigan. C. H. BENNING, M.D. Michigan Public Health, 12: 4, 149, April 1924. Account of an outbreak of some 35 cases of typhoid in mining town of 1800 inhabitants in Upper Michigan. Outbreak was confined to section of town supplied with unpurified river water. Inhabitants had been warned not to use this supply for drinking purposes; but warning was unheeded. Emphasizes danger of accessible polluted supply, and fallacy of belief that warning against use of such water will be heeded.—*E. S. Chase.*

Division of Sanitation. (N. Y.) N. Y. State Dept. of Health Quarterly, 1: 1, 30, April 30, 1924. Brief summary of activity of Division in 1923. Refers to fact that drought of that year resulted in serious shortage of water in various municipalities, with consequent use of emergency supplies from polluted sources. Emergency chlorine apparatus were installed, in some cases by the municipality, and in others, by the Division. One municipality experienced a serious outbreak of intestinal diseases due to pumping of polluted water into mains.—*E. S. Chase.*

Report of Division of Sanitary Engineering. (Va.) RICHARD MESSER. Virginia Health Bulletin, 16: extra No. 6, April, 1924. Reprint biennial report of State Board of Health for 1921-1923. Reviews activities of Division and gives much detailed information regarding water supplies of Virginia. Refers to fact that only one small water borne outbreak of typhoid occurred in Virginia in three successive years. Describes an interesting experience at Charlottesville, with purification plant consisting of slow sand filters, filtered water aerator, and chlorination. Plant was installed in 1922 to remove algae, odors, and color. Satisfactory results were obtained for about 1 month; when color of filtered water became higher than that of raw. Trouble due to iron, which originated in reservoir in organic combination and was deposited in filters in zone devoid of oxygen and rich in carbon dioxide. This resulted in solution of iron and saturation of the sand bed therewith, to be followed by unloading of accumulated iron. Scraping and aeration of beds were found to be a temporary remedy only. As result of investigation, spray nozzles for aeration of raw water prior to filtration have been installed.—*E. S. Chase.*

The Determination of Manganese in Water. W. D. COLLINS AND MARGARET D. FOSTER. Ind. Eng. Chem., 16: 6, 586, June, 1924. Use 100 cc. of water, or such portion as will contain less than 0.1 mg. of manganese. Add 10 cc. dilute nitric acid (1 part strong acid to 3 of water), 1 cc. concentrated sulfuric acid, and heat in beaker on hot plate to drive off most of sulfuric acid. Cool, take up with about 50 cc. water and 20 cc. dilute nitric acid through which air has been bubbled to remove oxides of nitrogen. Add 0.10 gm. sodium bismuthate, stir for 1 or 2 minutes, allow excess bismuthate to settle, and

filter through alundum, or through Gooch crucible with mat of ignited asbestos, treated (by filtration) with permanganate solution and then washed. Dilute filtrate to definite volume and compare with standards prepared from appropriate volumes of standard permanganate solutions, containing the same quantity of nitric acid, as used for the sample, and adjusted to same volume. The reasons for the various modifications are explained in the discussion.—*Linn H. Enslow.*

Chemical Exchange Reactions of Zeolite. C. J. FRANKFORTER AND FRED W. JENSEN. *Ind. & Eng. Chem.*, 16: 6, 621, June, 1924. Replacement of sodium of zeolites by other metals such as barium, calcium and magnesium, is strictly stoichiometric. This is regarded as evidence that the reaction is not due to absorption phenomena. Base exchange in highly dilute solutions, such as natural waters, is more nearly complete than at greater concentration, thus indicating ionic reactions. Barium showed approximately four and one-half times the replacing power of calcium when both were present in chemically equivalent amounts. The variation in composition of the zeolites studied renders any definite statements as to their exact chemical constitutions impossible. The general formula given by manufacturers was $2 \text{SiO}_2 : \text{Al}_2\text{O}_3 : \text{Na}_2\text{O} : 6\text{H}_2\text{O}$.—*Linn H. Enslow.*

Bleaching Powder Explosions. AUGUSTUS H. GILL. *Ind. & Eng. Chem.*, 16: 6, 577, June, 1924. Investigation of cause of explosion of cans and drums of bleaching powder has revealed following facts. Oxygen evolution by decomposition of CaCl_2O_2 produced in some cans pressures up to 13.6 pounds per square inch, corresponding to not more than 0.7 per cent of contents of can. Oxide of iron if present acts as a catalytic agent, increasing the rapidity of gas formation. Oxide of manganese plays a similar role, but to a lesser degree; on the other hand, a mixture of the two oxides is more powerful than either alone. Calcium chlorate, which is always found to some extent in bleaching powder, also increases and prolongs oxygen evolution. Analyses of various samples of bleaching powder which had caused explosions showed presence of manganic, as well as of ferric oxide.—*Linn H. Enslow.*

Electric Motors for Driving Centrifugal Water Pumps. ERIK G. SOHLBERG. *Chem. & Met. Eng.*, 30: 21, 832-3, May 26, 1924. Large users of pumped water generally find it more economical to install motor-driven centrifugal pumps, purchasing power from some local electric service corporation. Reasons are; lower first cost, lower fixed charges, lower cost of maintenance, lower cost of operation, and higher efficiencies in case of large central station. When everything taken into consideration, motor-driven centrifugal pumps will operate at about 76 per cent of cost of reciprocating engines and plunger pumps with boiler plant.—*John R. Baylis.*

Why Caustic Solutions Make Steel Brittle. R. S. WILLIAMS AND V. O. HOMERBERG. *Chem. & Met. Eng.* 30: 15, 589-91, April 14, 1924. Continued use of waters containing sodium bicarbonate often leads to intercrystalline cracks in riveted joint areas. Mild steel is made distinctly brittle, under

influence of cathodic hydrogen. In the investigation, an external electromotive force was used to increase quantity of cathodic hydrogen. Four per cent caustic soda was placed in contact with one side of a test bar and distilled water with the other. Both solutions were protected from the air. Gaseous hydrogen that penetrated through the $\frac{1}{4}$ -in. specimen into the distilled water was collected and measured. The difference in rate of penetration when in strained, and when in unstrained, condition was quite marked. Slag in mild steel was acted upon rapidly. Conclusions:—During crystallization of steel, the impurities, to a considerable extent, are rejected to grain boundaries. Oxides and sulfides are two of prime factors in caustic embrittlement: oxides are reduced under influence of cathodic hydrogen; sulfides are removed by caustic soda, thereby rendering conditions favorable for progressive corrosion. Hydrogen conduces in three ways thereto; (1) by the temporary embrittling effect of absorbed hydrogen; (2) by oxide reduction; and (3) by effecting changes in volume at grain boundaries.—*John R. Baylis.*

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